TOCKLAI EXPERIMENTAL STATION

TEA RESEARCH ASSOCIATION CALCUTTA

ANNUAL SCIENTIFIC REPORT 1982-83

Our Cover

Tea under Su-babul (***Leucaena leucocephala*** (Lam.)) shade

Annual Scientific Report

Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April, 1982 to 31st March, 1983. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T.R.A., Calcutta.

TOCKLAI EXPERIMENTAL STATION
JORHAT 785008, ASSAM, INDIA

August 1984

Published by
TOCKLAI EXPERIMENTAL STATION, JORHAT, ASSAM, INDIA
and Printed at ASSAM PRINTING WORKS (P) LTD., JORHAT 785001

Contents

Director's Report

(1st April 1982 to 31st March 1983)

Senior Staff

On the 31st March, 1983, the Senior Staff consisted of :

Director
Dr. N. K. Jain, M.Sc.Ag.(B.H.U.), Ph.D.(Illinois), C.P.Ag.(USA)

Adviser
Dr. D.N. Barua, B.Sc.(Calcutta), Ph.D.(Cantab)

Advisory:

Located at Tocklai

Head of Department :
Mr. S. K. Sarkar, B.Sc.(Calcutta), B.Sc.Ag.(B.H.U.)

Assistant Advisory Officers
Dr. N. Borpujari, M.Sc.Ag.(A.A.U.), Ph.D.
Mr. S. D. Basu, M.Sc.(Calcutta)
Mr. M. B. Tamang, M.Sc.(N.B.U.)

Assistant Training Officer
Mr. B. N. Gogoi, B.Sc.(Guwahati)

Agronomy:
Estate Manager-cum-Assistant Agronomist
Mr. A. K. Bhargava, M.Sc.(Agra)

Soils & Meteorology :
Head of Department
Mr. S. K. Dey, B.Sc.(Calcutta), Assoc. I.A.R.I.
Assistant Soil Scientists
Mr. N. G. Bhattacharjee, B.Sc.(Calcutta)
Dr. A. Sen, M.Sc., Ph.D.(I.A.R.I.)

Botany:
Head of Department
Dr. H. P. Bezbaruah, M.Sc., Ph.D.(Guwahati)
Plant Physiologist
Dr. L. Manivel, M.Sc.Ag. (Madras), Ph.D. (California)

Plant Protection :
Head of Department
Dr. G. Satyanarayana, B.Sc.(Hons.) (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.
Assistant Entomologist
Mr. S. C. Das, M.Sc.(Calcutta)

Biochemistry:
Biochemist
Dr. S. D. Ravindranath, M.Sc.(Mysore), Ph.D. (I.I.Sc., Bangalore)

Assistant Biochemists
Dr. M. R. Ullah, M.Sc., Ph.D. (Guwahati)
Dr. P. K. Mahanta, M.Sc.(Guwahati), Ph.D. (Guwahati)
Dr. M. N. Dev Choudhury, B.Sc. Guwahati M.Sc. (Dibrugarh), Ph.D.(A.A.U.)

Tea Tasting:
Tea Taster
Mr. R. P. Basu

Second Tea Taster
Mr. A. K. Das, B.A.(Guwahati)

Engineering Research & Development :
Head of Department
Mr. T. C. Baruah, B.Sc.(Hons.) (Guwahati), B.Sc. Mech. Eng. (B.H.U.), M.Sc.Mech. Eng. (Manchester)

Statistics:
Head of Department
Mr. A. K. Biswas, M.Sc.(Guwahati)

Agricultural Economics:
Agricultural Economist
Dr. R. C. Awasthi, M.Com., LL.B., Ph.D.(Agra)

Nagrakata Sub-Station

Deputy Director
Dr. B. Banerjee, M.Sc., M. Sc.D(S.Illin.), Ph.D. (Lond.), F.A.Z., F.R.E.S. (Lond.) FNASc (Ind)

Advisory Officer
Mr. B.C. Phukan, B.Sc.Ag. (Guwahati), A.I.F.C.

Advisory Officer
Dr. P. N. Rustagi, B.Sc. (Hons.),M.Sc., Ph.D.(Delhi)

Water Technologist-cum-Soil Scientist
Dr. B. Singh, B.Tech.(Pant Nagar), M.Tech. (I.A.R.I.), Ph.D.(Newcastle)

Plant Breeder-cum-Agronomist
Dr. I. D. Singh, M.Sc.Ag.(Agra), M.Sc. (Guelph), Ph.D.(Georgia)

Assistant Soil Scientist
Mr. A. K. Sen Gupta, B.Sc. (Hons.) (Calcutta)

Advisory Centres

Darjeeling Advisory Centre :
Assistant Advisory Officer
Mr. R. Das Gupta, B.Sc.Ag. (Ranchi), M.Sc.Ag. (Bhagalpur)

Terai Advisory Centre:
Assistant Advisory Officer
Dr. S. Basu, B.Sc.(Calcutta), M.Sc.Ag. (Calcutta), Ph.D.(Calcutta)

Cachar Advisory Centre:

Advisory Officer
Mr. B. Borthakur, M.Sc.Ag.(Guwahati)

North Bank Advisory Centre :
Advisory Officer
Mr. B. C. Barbora, M.Sc.Ag.(I.A.R.I.)

Upper Assam Advisory Centre:
Advisory Officer
Mr. J. Chakravartee, M.Sc.Ag.(Guwahati)

Tripura Advisory Sub-Centre:
Assistant Advisory Officer
Mr. S. C. Dey

Service Departments

Administration:
Administrative Officer
Group Captain K. R. Gopalan (Retd.)
Assistant Administrative Officer
Mr B. S. Kotoky, B.A., LL.B.(Dibrugarh)

Accounts:
Additional Accounts Officer
Mr. K. Banerjee

Library & Publication:
Librarian & Assistant Publication & Information Officer
Mr. J. N. Sharma, M.A.(Guwahati)

Maintenance:
Assistant Station Engineer
Dr. H. K. Barua, M. Tech.(Structural Engg.), Ph.D. (Kharagpur)

Medical :
Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Planning:
Assistant Planning Officer
Mr. A.R. Sarkar, B.Sc.(Calcutta)

SENIOR STAFF MATTERS

Appointment

Mr. K. Banerjee joined as Additional Accounts Officer on 1.1.83.

Retirement/Resignation

Dr. T. K. Ghosh, Head, Agronomy Department retired with effect from 1.11.82.

Mr. O.P. Shukla, Accounts Officer resigned on 4.5.82

TRAINING AND LECTURE COURSES

Six Weeks' Training in V.P.

One Course from 1.10.82 to 14.11.82 —9 trainees attended

Three Months' Training for Supervisors

1st Course from 1.3.82 to 31.5.82 —12 trainees attended

2nd Course from 11.10.82 to 31.12.82 —8 trainees attended

Field Management Course for Planters

1st Course from 2.8.82 to 5.8.82 —27 planters attended

2nd Course from 9.8.82 to 12.8.82 —21 planters attended

VISITORS

Mr. D. J. O'Connor, Warren Tea Ltd., Deohall T.E.

Mr. S. Nagaraju, Senior Scientific Officer (Stat)., P.B. No. 2273, Tumkur Road, Bangalore.

Mr. A. K. Mandal, Dy. Project Manager, PCLA New Delhi.

Mr. H. K. Madan, Engineer, IIP, Dehradun.

Dr. P. C. Dutta, Professor Emeritus (IUCS)

Mr. R. L. Stone-Wigg, James Finlay & Co. Ltd., Glasgow.

Mr. Len Bates, Burel Betsy Lane, Bransgore, Christ Church, Dorset, England.

Dr. H. K. Saksena, Prof. & Head, Plant Pathology (Deptt.), C.S.A. University of Agriculture, Kanpur.

Mr. R. Seetharaman, Project-Director, AICRIP, Hyderabad.

Dr. C. Krishna Rao, Ex-V.C., A.P.A.U., Hyderabad

Dr. Kishan Singh, Director, I.I.S.R., Lucknow.

Mr. S. K. Mukherjee, Chairman, QRTNEH, ICAR Complex.

Prof. D. V. Tamhane, University, Deptt. of Chemical Technology, Matunga Road, Bombay 400 019.

Prof. S. K. Majumdar, Dept. of Food Tech. & Biochemical Eng., Jadavpur University.

Dr. K. M. Jain, 1, Doctor's Lane, New Delhi-1.

Dr. Balaram Bose, Professor, Mechanical Engineering, Jadavpur University, Calcutta-32.

Mr. N.S.R. Anjaneyulu, G.M., Hindustan Fertilizer, Namrup.

Mr. A.S. Chatha, General Project Manager, M/s. HFL, Namrup.

Dr. M. Satyanarayana, Professor & Head, Chemical Engg. Deptt., I I T, Madras 600 036.

Mr. G. Hanumantha Rao, EM-EM Electronics 66, Chandralok Complex, Secunderabad, A.P.

Dr. S. K. Basu, Director, Central Mechanical Engineering Research Institute, Durgapur-9.

Mr. R. K. Krishna Kumar, Tata-Finlay Ltd.

Mr. V. N. Bahal, Tata-Finlay Ltd.

Mr. D. Raj, Duncans Agro Industries Ltd., Calcutta

Mr. C. J. Hanes, Brooke Bond Group P.L.C. London.

Mr. T. C. Bora, Doom Dooma India Ltd.

Mr. C. R. Kamath, Larsen & Toubro Limited, Powai Works, Saki Vihar Road 400 072.

Dr. K. K. Mitra, Tea Board, Calcutta.

Dr. R. Thiagarajan, Director (I & D), Dept. of Science & Technology, New Delhi 110 016.

Surgeon Captain Jagjit Singh, Senior Advisor in Paediatrics, Command Hospital (EC) Calcutta 700027.

Prof. Indradev, C.S.I.R., Rafi Marg, New Delhi.

Mr. Pradip K. De, U.S. Information Service, Calcutta 700013.

Mr. R.C. Punshi, Duncans Agro Industries Ltd., Calcutta-1.

Mr. Ramveer Singh, Macneill & Magor Ltd., Calcutta.

Mr. A. P. Lahiri, McLeod Russel (India) Ltd.

Mr. S. K. Sharma, Octavius Steel & Co. Ltd., Calcutta.

Mr. N. G. Gupta, Goodricke Group Ltd.

Dr. Margaret C. Anderson, CSIRO Division of Water & Land Resources, P.O. Box 1666, Canberra, A.C.T. 2601, Australia.

Mr. Sushil Krishna Garg, Indian Chamber of Commerce, India Exchange, Calcutta-1.

Mr. A. K. Basu, Director Financer, Andrew Yule & Co. Ltd., Calcutta.

Mr. C. Chhabra, Advisor, Macneill & Magor Ltd., Keyhung, Assam.

Mr. V. N. Singhania, Bazaloni Group Ltd., 23 Ganesh Chandra Avenue, Calcutta-13.

Mr. S. K. Saraf, Bazaloni Group Ltd., 23, Ganesh Chandra Avenue, Calcutta-13.

Mr. S. Kar, Bazaloni T.E., Makum Jn.

Mr. Dambarudhar Pathak, Chief Justice of Gauhati High Court.

Mr. C. R. Das, Secy. to Chief Justice, Gauhati.

Mr. Nripen Das, Registrar, Gauhati High Court.

Mr. S. Haque, District/Sessions Judge, Jorhat.

Mr. T. Bhuyan, Addl. District Judge, Jorhat.

Mr. B. K. Das, Addl. D.C. Sibsagar, Jorhat.

Mrs. R. Kalita, Jorhat.

Mrs. K. Das, Gauhati.

Mr. Gian Chand, Secretary, N.E.C.

Mr. R. N. Jandon, Project Economist, N.E.C.

Mr. D. N. Chakravarty, Director, I & PR, N.E.C.

Air CMDE K.D. Kawagat, AOC, No. 10 Wing, A.F.

Mr. S. M. Kidwai, Tata Tea Ltd., 1 Bishop Lefroy Road, Calcutta.

Mr. B. Dutt, Superintendent, Makum/Namdung, Margherita.

Group & Individual Visits

Dr. B. Banerjee, Deputy Director, Nagrakata Substation, attended ISI Meeting on Pesticide formulation at New Delhi and International Seminar on Synthetic Pyrethroids at Delhi on invitation of French Embassy.

Mr. A. K. Biswas, Head, Statistics Department attended the Conference at Indian Statistical Institute, Calcutta (26.9.82 to 1.10.82); visited Regional Computer Centre, Calcutta in connection with the job of the depatment carried out there and also visited ORG Installation, Calcutta (2.10.82 to 5.10.82) in connection with Mini-Computer. Also he and Mr. D.K. Sanyal of Statistics Department attended the A.G.M. of T.R.A., Calcutta on 6.10.82. He attended the J.A.S.C. Meeting in Cachar from 5.11.82 to 7.11.82.

Dr. L. Manivel, Plant Physiologist and Dr. S.C. Das, Senior Scientific Assistant of Botany Department, Tocklai attended the International Workshop Treephysindia 1982, held at Rubber Research Institute, Kottayam and presented papers on methodological problems of Research on Photosynthesis translocation and dormancy in tea respectively.

Dr. P. N. Rustagi, Advisory Officer, Dooars & Goalpara, participated in Districts seminar for gardens of Eastern Dooars at Kalchini Club on 16.9.1984 and District seminar for Terai gardens at Bengdubi Club on 7th October, 1982. He attended Joint Area Scientific Committee Meeting in Cachar on 5-7th Nov. 1982; AGM of Dooars Branch of Indian Tea Association at Central Dooars Club on 15th January 1983 and participated in District seminar for Terai, Dooars and Goalpara gardens at Central Dooars Club on 4th March 1983.

Dr. B. Singh, Water Technologist-cum-Soil Scientist, visited Asian Institute of Technology on the assignment of Govt. of India, Ministry of Education for 3 months and offered an advanced course on "Agricultural Drainage System Design" to post graduate students of Engineering. He also delivered lectures to participants of "Farm Water Management Course" sponsored by E.E.C. & A.I.T. at Bangkok.

Dr. I. D. Singh, Plant Breeder-cum-Agronomist, Nagrakata Sub-station, visited Gurjangjhora Tea Co. Ltd., Jalpaiguri on 6 & 7th May, 1982 to attend Company's Centenary Celebration and Seminar on Tea; Area Scientific Committee Meeting, Darjeeling on 4th April, 1982 and District Seminar at Bengdubi Club, Terai on 7th October, 1982.

Representation on Various Bodies (1982-1983)

Dr. N. K. Jain		
Member	:	Editorial/Advisory Board of Indian Journal of Agricultural Research, Karnal
		Indian Society of Agronomy
		American Society of Agronomy
		Crop Science Society of America
		Soil Science Society of America
		C.P. Ag. of ARCPACS, Madison, WI, USA
		Tea Research Liaison Committee of the Tea Board (India)
		Indian Science Congress Association, Calcutta
Dr. B. Banerjee		
Expert Member	:	International Panel studying the impact of climatic function of food crop.
Correspondent	:	International Society for Statistical Ecology
Fellow	:	Royal Entomological Society of London
		National Academy of Sciences, India
Member	:	British Ecological Society
		Ecological Society of America
		Society of Population Ecology, Tokyo
Mr. T. C. Baruah		
Member	:	I.S.I. Committee on Specifications of power sprayers and CTC segments
		Scientific Panel, Indian Plywood Industries Research Institute, Bangalore
Mr. A. K. Biswas		
Member	:	Indian Statistical Institute, Calcutta
		Indian Standards Institution, New Delhi
		Selection Board of I.C.A.R., New Delhi
Dr. R. C. Awasthi		
Member	:	International Agricultural Economics Association
		Indian Society of Agricultural Economics, Bombay
Mr. A. R. Sarkar		
Life member	:	Indian Statistical Institute Alumini Association, Calcutta
Dr. L. Manivel		
Member	:	American Society for Horticultural Science
Mr. S. K. Dey		
Member	:	British Society of Soil Science
		Indian Society of Soil Science
		International Society of Soil Science
		Indian Society of Plantation Crops
		Indian Society of Agricultural Engineers
Dr. G. Satyanarayana		
Fellow	:	Indian Botanical Society
		Indian Phytopathological Society
Member	:	American Phytopathological Society
		British Mycological Society
		Federation of British Mycologists
		Agri-Horticultural Society of India
		Indian Mycological Society
Dr. H. P. Bezbaruah		
Member	:	Botanical Society of America
		Indian Society for Plantation Crops
Mr. B. S. Kotoky		
Member	:	Indian Institute of Public Administration
Dr. B. C. Barbora		
Member	:	Indian Society for Plantation Crops

Mr. S. C. Das
Member : Plant Protection Association of India

Dr. S. D. Ravindranath
Member : Society of Biological Chemists of India

Dr. M. R. Ullah
Member : Society of Biological Chemists of India

Dr. P. K. Mahanta
Member : Society of Biological Chemists of India

Dr. M. N. Dev Choudhury
Member : Society of Biological Chemists of India
Society of Plant Physiology and Biochemistry of India, (I. A. R. I., New Delhi.)

Dr. B. Singh
Member : Indian Society of Agricultural Engineers
Society of Indian Soil and Water Conservationists
Technical Committee No. AFDC 47 (Agricultural Farm Drainage) of Indian Standards Institute, Govt. of India, New Delhi

Dr. I. D. Singh : Indian Society of Genetics and Plant Breeding
Member Indian Society for Plantation Crops
The Northern India Science Association
Society of the Sigma Xi
Plant Breeding Society
American Institute of Biological Sciences
American Society of Agronomy
Crop Science Society of America

Dr. A. Sen
Life member : Indian Society of Agriculture, Calcutta

Library & Publication

The Tocklai Central Library supplied regularly books and other publications to the Departments and out-station branches. During the period, 86 new books were added to the existing collection. Two new journals have been added to the subscription list raising the total number to 162. A total of 165 journal titles including annual reports, technical reports, pamphlets, bulletins were received on free/exchange basis.

Library statistics

Books added during the year	86
Journal volumes received on subscription basis	1034
Journal volumes received on free/exchange basis	437
Pamphlets and bulletins	411
Annual reports and Technical reports	64
Reprints	32
Photocopies procured	16 pages
Xerox copies made	584 pages
Translations procured	1
Publications issued to Department	1470
Publications consulted in library	1720
Journal volumes bound	133

LIBRARY SERVICE

Library services were extended to the Tocklai scientific personnel, three months trainees, V.P. trainees, drainage trainees and other persons who attended lecture courses held at Tocklai. Teachers, students, research scholars, and scientists from the local university, colleges, research laboratory and other organisations made use of the library facility extensively. Research scholars and students from Gauhati University and Dibrugarh University, scientists from the Regional Agricultural Research Station, Shillongani (Nowgong) and a consultant from the Indian Tea Association, Calcutta also utilised the library services.

DOCUMENTATION & INFORMATION

Library accession lists showing titles of the publications received in the library were circulated among the Departments. Four issues of 'Documentation List'—listing current periodical articles relating to tea science and allied subjects, and one 'Bulletin of Documentation on Tea'—a list of abstracts of important articles on tea were circulated among the scientific staff of Tocklai and out-station branches. More than five hundred references have been added to the 'Bibliography on Tea' in card form.

Press cuttings relating to tea and allied subjects and classification and cataloguing of books were continued.

A total of 584 pages of xerox copies were made during the year under report. The number is far below than the one reported last year. This was due to break down of the Toshiba plain paper copier and the difficulty in maintaining the machine in serviceable condition. The need for a replacement is strongly felt as there is regular demand from the scientific staff for photocopies.

PUBLICATION

The following were published from Tocklai during the year 1st April 1982 to 31st March 1983:

1. **Two and A Bud**
   Vol. 28 No. 2 December 1981
   Vol. 29 No. 1 June 1982
2. **Memorandum**
   No. 29 (Revised): Some Common Weeds of the Tea Estates in North-East India
   by Ananda Chandra Dutta 1983
3. **Miscellaneous Reports**
   (a) Engineering Research & Development Department Quarterly Reports for quarters ending 30th June, 30th September, 31st December 1982 and 31st March 1983 (Cyclostyled).
   (b) Proceedings of the Twenty-Ninth Conference held at Tocklai on December 17 through December 19, 1981.
4. **Tea Encyclopaedia Serials**
   (a) 112/2 Ants And Their Nest (revised).
   (b) 119/1 Diseases of Green Crops In North-East India & Their Control (revised).

Highlights

(1) *Increasing awareness towards, efficient drainage system.*
(2) *Acceptance of definite pruning cycles of 3 to 4 yrs based on the requirement and suitability of the area.*
(3) *Consolidation of old sections by either medium pruning and infilling or rejuvenation pruning and infilling.*
(4) *Improvement in the standard of young tea management.*
(5) *Popularisation of the proven planting materials in new plantations.*
(6) *Acceptance of mulching of young tea as a routine practice.*
(7) *General improvement of plucking standard and awareness about maintenance foliage.*
(8) *Identification of constraints in the success of V.P. nurseries.*
(9) *Awareness about balanced manuring.*
(10) *Identification of causes of failure to establish a good stand of shade in young tea areas.*

GENERAL

The Advisory Department has introduced a major change in its approach towards solving the field problems of the members estates. The various causes responsible for shortfall in obtaining optimum response from different agrochemicals and agricultural practices followed such as pruning, plucking, soil rehabilitation, drainage young tea management etc. that were encountered by estates were critically examined and identified. The advises which were primarily need based were formulated taking into account the soil climatological factors prevailing in the region and resources available with the estates. Our efforts paid handsome dividends. The advisory services were more keenly sought than ever before.

The Advisory Department organised ASC meetings and seminars and also organised field demonstration-cum-seminars on the current recommendation of Tocklai on plucking, pruning, spraying etc. for the supervisory staff/sirdars of tea estates.

Advisory Visits

The number of advisory visits declined to some extent in both North and South Bank due to further decline in membership. The uneasy situation prevailing in Assam during the year had also some impact on these visits but our Advisory Officers rose to the occasion by continuing their services sometimes even under trying conditions. In Cachar and Tripura the number of advisory visits did not decrease to the same extent as that of the decline in membership. (Table 2.01).

Area Scientific Committee Meetings and Seminars

The Area Scientific Committee Meetings and Seminars held during the year in different areas are shown in Table 2.02.

Table 2.01. *Details of Advisory visit paid to the member estates during 1981-82 and 1982-83.*

District	Total number of member estates		No. of Member estates visited d ring		Total No. of visits paid during	
	1981-82	1982 83	1981-82	1982-83	1981-82	1982-83
South Bank (including Upper Assam)	311	293	230	214	402	357
North Bank	79	70**	70	62	131	124
Cachar & Tripura	69	50	67	67	245	212
Total	459	418	367	343	778	693

**excludes Goalpara estates

Table 2.02 *Number of ASC meetings and seminars on different topics and the number of participants.*

Area	Date	Topics of Seminars	No. of planters participated
South Bank I	11-8-82	Agriculture, Soils & Botany	95
	6-4-82	Engineering & Manufacture	61
South Bank II	10-8-82	Agriculture, Soils & Botany	45
	7-4-82	Engineering & Manufacture	46
South Bank III	24-5-82	Agriculture, Soils & Botany	46
	26-8-82	Engineering & Manufacture	64
North Bank East	14-6-82	Agriculture, Botany & Plant Protection	48
West	16-6-82	Agriculture, Botany & Plant Protection	28
East & West Combined	11-10-82	Agronomy	62
Cachar	17-4-82	Committee Meeting in Connection with J.A.S.C.	
	5-6-82	—do—	
	5-7-82	Plant Protection	83
	1-9-82	Committee Meeting in Connection with J.A.S.C.	
	1-12-82	—do—	
	5-11-82 to 7-11-82	Joint Area Scientific Committee Meeting.	150

Lecture Courses

The following lecture courses were organised by the Department with the help of specialist Officers.

Field Management Course : Two courses each of 4 days duration during the year. 48 planters attended which was much higher than last year.

Surveying & Drainage Course : Due to the prevailing situation in Assam this course could not be held.

Training Courses for Supervisory Staff of Tea Estates

The training courses for supervisory staff of tea estates through field demonstration-cum-seminars were continued this year also though on a limited scale. This year's training programme was confined in those areas only wherefrom special requests were made for such a training as the Asstt. Training Officer had to

take charge of all the other training programmes that are being run at Tocklai.

Fig 1. Plucking demonstration in a member tea estate of Assam

Tipping and plucking demonstrations were organised in the tea estates of Goalpara District in North Bank. The number of participants is given in Table 2.03.

Table 2.03. *Participation in tipping & plucking demonstrations*

Region	No. of demonstrations	No. of participants	No. of tea estates represented
North Bank	5	86	5

Pruning and skiffing demonstration were held in Upper Assam and South Bank. The number of participants regionwise is given in Table 2.04.

Table 2.04. *Regionwise participation in pruning and skiffing demonstrations.*

Region	No. of demonstrations	No. of participants	No. of tea estates represented
Upper Assam	7	342	57
South Bank	4	215	29
Total	11	557	86

Demonstrations on spraying technique were held at 2 centres in Terai. The number of participants is given in Table 2.05.

Table 2.05. *Participation in spraying technique demonstrations*

Region	No. of demonstrations	No. of participants	No. of tea estates represented
Terai	2	78	13

Distribution of cuttings

The details of distribution of cuttings, scions, generative clones and seeds from Tocklai and various outstations to member estates, Tea Board and other State Governments are given in Table 2.06.

Table 2.06. *Distribution of cuttings, scions, generative clones and seeds from Tocklai and outstations.*

Tocklai	V.P. Cuttings	Scions	Generative Cuttings	Generative Scions	Seeds in Kg
Upper Assam	1,740	—	—	—	—
South Bank (Tocklai)	—	—	—	—	—
North Bank	2,82,597	675	10 000	—	—
Cachar	3,80,310	—	600	—	—

Comments on Agricultural Practice

Land Planning and Drainage

Increasing awareness was observed on the need of an efficient drainage system and the adverse effects of poor drainage. To improve the drainage status of existing tea areas widening and deepening of the main and subsidiary drains, grading of drain beds etc. were being done as routine measures. A few estates did bunding to prevent overflow of excess water from the rivers flowing close by.

Restricted outfall, adversely affecting the functioning of the drains, continued to pose problem in almost all the areas in Assam. In many estates this problem was overcome, at least partially, by regrading and realigning the collector and submain drains. These measures, coupled with widening of the main and subsidiary drains helped to improve upon the situation to a great extent in certain estates. Some estates where such measures were not likely to achieve results were advised to divert the flow of water by identifying alternative outfall based on Survey to reduce the volume of discharge in the existing main drain.

In most estates of North and South Bank only marginal land is available for extension planting. As such there had been a greater awareness among planters for making use of the best available know how in respect of drainage, soil rehabilitation, conservation and improvement of soil tilth. For laying out drains on new extensions and replanted areas services of surveyors were generally sought for.

In Tripura most of the estates do not have any problem of high water table. The drainage system was therefore designed to take care of the surface run-of water on the high land and tillahs with perimeter drains on the flats to prevent seepage. According to the ideas given by us in the recent past low cost dams were constructed by certain estates in Cachar and Tripura and the water was fruitfully utilised for irrigating the tea areas on the adjoining tillahs. This proved to be extremely helpful for young tea in the formative period of its growth.

Pruning Cycle

By and large, the pruning policy adopted in the estate did not show any significant deviation from that in last year. In both North and South Bank three to

four years cycles were generally being followed, three year cycle for youngish vigorous teas and four year cycle for oldish teas. However, a large number of quality concious estates followed strictly a three year old cycle of LP-DS-MS. Some estates using clones like P126A, N436 etc. and large scale followed a three year cycle of LP-DS-DDS.

In Cachar, a three to four years cycle was generally practised in most of the estates with one or two unpruned year intervening in the cycle.

In Tripura where a definite pruning cycle was almost non existent until a few years back, most of the estates, having realised the benefit of a well laid out pruning cycle, have formulated one suitable for the individual estate. During advisory visits, however, the ill effects of adopting a cycle longer than 4 years was stressed and the benefit of having a 3-4 years cycle was emphasized

Rejuvenation

Rejuvenation pruning, need as an effective tool for revitalising old tea sections and bringing it back to the level of economic productivity continued to be practised in many estates in Assam. In North Bank, however, the estates in general gave preference to medium pruning at 55cm over rejuvenation pruning which was followed by consolidation with infilling. This operation coupled with advance improvement of drainage and shade as advised by the Advisory officers gave quite encouraging results.

As reported last year the success of rejuvenation or even for that matter medium pruning is dependant on the adoption of pre- and post-operative measures. Moreover, infilling being an integral part of these operations, vigorous and high yielding planting materials of proven merit are only to be used for infilling. It could be observed that certain estates used a few less vigorous clones known for their quality only for infilling and as such desired results could not be achieved. However, during advisory visits it was pointed out that for infilling in mature tea areas one should use well grown plants of high yielding vigorous clones such as TV19, TV22, TV23, TV25, TV26 etc.

In Cachar rejuvenation pruning had gained further momentum in last year because of the successful initiation of this operation by a few leading estates and introduction of Tea Board's Subsidy Scheme.

Rejuvenation pruning however, has not gained similar popularity in Tripura. But even then, as in last year, four more estates carried out this operation in limited areas and the initial response appears to be more encouraging.

Young tea

The conventional method of bringing up young tea recommended by Tocklai involving centering out, frame forming prune and step up plucking has become more or less the general practice in most of the estates. In spite of this, however, the expected yield level of about 3500 Kg/ha in youngish mature tea has not been obtained in general, though in certain sections in a few estates this high yield level was achieved. The limitations in achieving this yield and to keep it sustained at that high level were observed to be due to the following factors:

(i) Indiscriminate use of planting material.
(ii) Use of sub-standard plants and small planting pit.
(iii) Poor soil rehabilitation and land preparation before replanting.
(iv) Poor root development of plants in the field starting from nursery stage.
(v) Over exploitation at the initial stages.
(vi) Faulty bringing up of young tea.

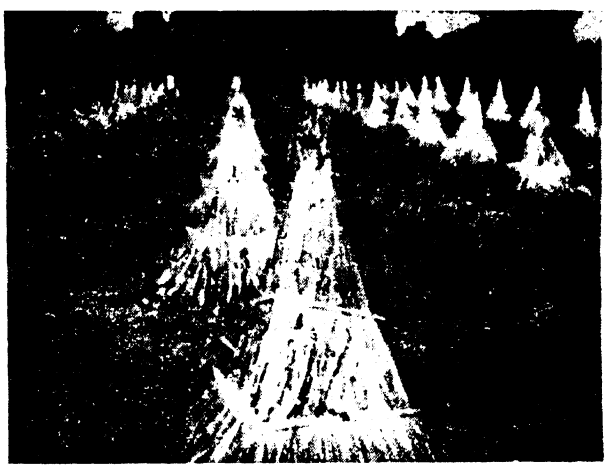


Fig 2. Newly planted stock 462 tea seed bari in a member estate of Tripura-protection against hot wind by thatch shade.

The persistent efforts of our Advisory Officers helped bring home to a few tea estates the need to correct all the above faulty cultural practices; they have taken them up quite seriously and have started adhering strictly to the correct planting methods and the subsequent upbringing of the young tea. Complete perfection in this regard, however, still eludes us. In Cachar usual early drought and poor soil fertility of the tillahs particularly where tea was grown in remote past are the two major constraints in bringing up the young tea to the desired level of growth and productivity. However, despite the above two constraints a few estates succeeded in bringing up young tea by adopting the set of practices laid down by us such as adequate soil rehabilitation in replanted areas, large planting pits, well grown vigorous plants, mulching, timely infilling of vacancies, adequate pest, disease and weed control etc.

Planting

In general, the popular planting materials were TV1, TV17, TV18, TV19, TV20, Tin Ali 17/1/54

and biclonal seed stock 449 and 450. In Cachar and Tripura TV1, TV18 and Tin Ali 17/1/54 and Dangri and Manipuri seeds are generally used. Besides some estates in Cachar has also tried biclonal seed stock 449 and 450. In some estates TV19, TV20, TV22 and TV23 have also received attention.

Fig 3. Spraying demonstration in a member estate of Cachar.

By the efforts of the Advisory and Asstt. Advisory Officers of Cachar and Tripura respectively two tea seed baries were established for the first time in Tripura in 1980 for producing seeds of Stock 449. Both the seed baries are doing well and harvest is expected during the autumn this year.

Plant population has been restricted to 14,000-18,000 plants/ha and an increasing conciousness has been observed against high plant population beyond 18,000 plants/ha. Double hedge planting found preference over single hedge.

In North Bank, wherever land was available extension planting was preferred to replanting and marginal land were also planted out by a few estates due to non-availability of good virgin land for extension planting. In Cachar as in the last year the extent of replanting has decreased while the replacement planting is on the increase. In Tripura although replanting is almost nil a small percentage of extension planting was carried out.

Small planting pits continued to be the common defect in planting in most of the estates inspite of stressing the importance of using proper size of pits by the Advisory Officers during their visits.

Mulching

Mulching of young tea has become an universally accepted practice in North East India. But, as in the past, dearth of adequate mulching materials continued; because of want of sufficient land most of the estates could not grow mulching materials enough for their use. Currently the loppings of guatemala grown mainly for soil rehabilitation serve as the main source of mulching materials in many estates. In their efforts to raise such materials as much as possible, many gardens made use of road sides and waste lands to the fullest extent. Water hyacinth and paddy straw were used as mulch for young tea by a few progressive concerns at a considerable cost.

In Cachar besides young tea, mature tea in the hot aspects of tillahs were also mulched by some estates. Any kind of available vegetative material were used as mulching which in fact, helped those estates to counteract the effects of drought effectively.

Through our persistent efforts, young tea in 90% member estates in Tripura were mulched, mainly with scrub jungles. However, materials being rather scanty and the areas to be mulched quite extensive, mulching, of necessity, had to be rather thin.

Plucking

In general standard plucking, as in the past, remained the order of the day. However, a few estates, in their pursuit of making quality tea, practised hard plucking even at the cost of some crop loss. The normal practice in most of the estate in Assam Valley was to pluck at 7 days round upto June and then at 9-10 days rounds for the remaining cropping period of the year. Whereas in Cachar plucking round varied from 7-10 days, in Tripura 9-10 days plucking round has been generally practised.

Leaving a leaf by the end of the season (Oct/Nov) for sections due for unprune in the following year has gained more popularity. It has been observed in certain areas that such stepping up helped the bushes to withstand droughty conditions better than those not stepped up. Tea estates in some drought prone areas preferred to step up at the beginning of the season after the drought was over and particularly when the maintenance foliage was poor.

It is a common observation that in sections where the topmost maintenance leaf remains erect-kharapat-the general practice is to break this leaf to half to make the plucking table flat. In the process of doing so, more often than not, this top maintenance leaf—which is the most active leaf for photosynthetic activities - gets torn off. It has been our constant endeavour to impress upon the planters that except when this kharapat tends to cover a growing shoot and thereby retard its growth rate, the practice of breaking the kharapat should rather be stopped. As a result, indiscriminate damaging of kharapat has been reduced to a great extent.

Vegetative propagation

Success in V.P. nurseries in general was satisfactory. In a few estates the success was not upto expectation due to lack of attention to details. Overcallusing

either due to excessive moisture or high pH of soil was reported from a few estates.

Nurseries with North light oriented overhead shade became the normal practice though some estates were still having nurseries with low lath frame or with flat root overhead shed. In Upper Assam both June/July and autumn cuttings are propagated and January/February cuttings were also found to be satisfactory. In South Bank an increasing tendency was observed in continuing vegetative propagation throughout the year except for a brief period of January/March.

Availability of suitable top soil for nursery has become a problem for many estates. In such a situation the concerned estates were advised to improve the soil condition through longer period of rehabilitation as well as by mixing sand and dry cattle manure with the soil.

The vegetative propagation is becoming increasingly popular in Tripura estates and during the period under review about 19 lakhs cuttings were planted by 11 member estates, an increase of about 46% compared to the previous year.

Manuring

The doses of nitrogen applied by different tea estates varied from 100-135 Kg/ha in Upper Assam and 80-150 Kg/ha in North Bank and South Bank. Phosphate was applied @ 20 Kg P_2O_5/ha pruned teas and potash application was on the basis of available potash status of the soil. However, estates of a few companies applied nitrogen at a higher dose ranging from 150 to 180 Kg/N/ha. The higher dose of nitrogen was invariably combined with higher doses of phosphate (20-40 Kg P_2O_5/ha) and potash (80-110 Kg K_4O/ha). Some of the estates in Upper Assam applied Magnesium Sulphate also.

In North Bank Zinc and Magnesium Sulphate were used as foliar sprays. The latter was also used with MOP to mitigate the effects of cold weather stress. In South Bank foliar application of Zinc Sulphate had become a routine practice in unpruned and lighter skiffed teas and in many estates Zinc was combined with Urea and MOP also.

Young tea manuring in most cases was as per Tocklai recommendation using either 2:1:2 or 2:1:3 NPK mixture.

In Cachar, application of nitrogen remained within the specified limit of 135 Kg/ha mostly in two splits when it exceeded 90 Kg/ha. Application of potash on the basis of soil analysis was however not carried out in many estates. Most of the estates have been applying rock phosphate at 40 Kg P_2O_5/ha for the last few years. Foliar application of Zinc in unpruned tea becomes a popular practice.

By and large the estates in Tripura still remain shy of manuring. Those few estates who manured their sections applied only nitrogenous fertilisers. While potash was applied at 60 Kg K_2O/ha in 4-5 estates, no phosphate was applied in any estate. However, during the time of moisture stress foliar application of Urea and MOP was done in many estates. Manuring in young tea sections was done mostly with Suphala (15:15:15 NPK), though for the last few years we have been stressing on the need for use of YTD (10:5:10 NPK) or NPK 10:5:15 for obtaining the optimum results.

Weed control

Glyphosate when applied at right dose and proper time gave excellent control of thatch grass, *Imperata cylindrica* and other obnoxious grassy weeds which constituted the major weed problem in many estates in Assam Valley. The broad leaf weeds were controlled mostly by spraying 2,4-D.

As regards application of pre-emergence herbicides, simazine failed to find wide acceptance in estates in North Bank. Karmex, the other pre-emergence herbicide recommended by us, when used at 2 kg/ha in mature tea in light soil has been reported to have caused toxic effects on tea in a couple of estates. The effectiveness of autumnal application of pre-emergent herbicide, as observed in some tea estates, casts a doubt about the economic benefits to be derived from it.

In South Bank (mid and lower Assam), on the other hand, autumnal application of Karmex as pre-emergence herbicide gave fair control of weed growth till June/July and appeared to be economical. The deletarious effects of contact herbicides like paraquat in young teas in the year of planting and the year following it when used without adequate care was observed in certain estate. To prevent such damages, the managements were advised to apply with due precaution even using a shield with the spray lance when necessary. Simazine toxicity in young tea was observed in certain sections having uneven land level and depressions in the ground.

In Cachar, weeds in the tea areas in the flats were controlled with paraquate and 2,4-D. Weeds on the slopes of tillahs were kept under suppressed growth either by using sublethal dose of herbicides or by only sickling. Due to nonavailability of Round-up control of *Imperata cylindrica* and other pernicious grassy weeds became a problem. The area under chemical weed control, however, was on the increase.

The manifold benefits to be derived from adequate weed control in young and mature tea areas at least from April to October were repeatedly explained to tea estates in Tripura; however, such advices are yet to be put into practice on a wide scale there. Manual weed control is almost universal in Tripura, though use of pre-emergent herbicides on a limited scale in

few estates was also reported. In the absence of chemical weedicides and because of lack of adequate manual control, heavy infestation of weeds persists in most of the estates, at least during monsoon.

Shade

An increasing awareness about the importance of raising, establishing and maintaining a proper stand of shade was observed in most of the estates. In the newly planted areas, both extension and replanting, shade planting was a regular work and the success in most of the estates was satisfactory. Those who failed to establish a good stand of shade in their young tea areas were largely due to lack of adopting proper silvicultural practices such as 1) Improper time of planting, 2) Small and weak plants used for planting, 3) Lack of proper control measures against pests and diseases both in the nursery and in the field, 4) Use of small planting pits and lack of proper manuring, 5)Damage by goat, cattle and human beings etc.

Fig 4. A well shaded young tea section in a member garden at Upper Assam.

Rehabilitation/realignment of permanent shade trees was taken up by a large number of estates in Assam Valley. *Albizzia odoratissima* and *Indigofera teysmanii* continued to be the most preferred permanent and temporary shade species respectively. The need for new permanent as well as temporary species of shade trees was felt by the industry.

Shade tree nursery of *A. odoratissima* and *A. lebbek* were raised in a few more estates in Cachar who did not raise them earlier for augmentation and replacement of old shade and also for planting shade—young tea areas.

In Tripura about 27 of the member estates took interest in quick improvement of the shade status of the poorly shaded mature sections by planting mainly with *Indigofera Teysmanii*. Young tea areas were shaded generally with *Tephrosia candida* and *Indigofera teysmanii*.

Pest Control

In North Bank seasonal incidence of Red Spider, Scarlet mite and Purple mite, Thrips, Greenfly and *Helopeltis* was reported. In a few districts Red Slug Caterpillar appeared in severe intensity and Looper Caterpillar was confined to a few isolated pockets only.

In South Bank (mid and lower Assam) no severe outbreak of any of the pests was reported during the year under review and only seasonal incidence of pests did occur.

In Cachar, Thrips infestation was on the increase during the year; besides, sporadic attack of scarlet mite was observed throughout the district. As usual severe infestation of Red Spider was observed gegerally in poorly drained and poorly shaded areas.

Termites continued to be the major pests in Tripura. However, because of limitations at third end, the estates succeeded in taking up control measures in only 50% of the pruned area, though we advised that all the pruned areas should be brought under control. Mild infestation of Red spider and thrips in mature tea and of Aphids and Greenfly in nurseries in some of the estates were observed.

Disease control

Primary root diseases continued to be a constant source of worry to the planters. However, in the absence of soil fumigant being made readily available to them, the estates had to make do with the control of these deadly diseases by uprooting the affected bushes and isolating the patches by digging drains all around.

In North Bank the incidence of both Red rust and Black rot were less than in last year. In South Bank, Red rust in young tea and *poria* in mature tea areas continued to be the major factors for poor growth and lower productivity.

In Cachar Red rust infestation in young tea on the flats continued to be prevalent but the extent of infestation declined in tillahs. The incidence of Black rot in the cooler aspects of tillahs remained predominant and posed a problem to the planters for its effective control.

In Tripura Red rust and Black rot were the two common diseases but their incidence was not widespread during the year under review.

Crop and Weather

The 1982-83 season, from crop point of view, was not very favourable. The early part of 1982 was dry due to scanty rainfall and on top of it low night temperature continuing upto April/May adversely affected the early crop. The loss of early crop was somewhat compensated as production picked up from July/August. The season, 1983, started with a promising note of a productive year, as the weather conditions during January to March was favourable for a good harvest, particularly in Upper Assam, South Bank, Cachar and Tripura.

SUMMARY OF RESULTS

Results of some of the experiments conducted by this Department in the member estates are given below:

1. Rejuvenation experiments

(i) South Bank (Assam): AS 128 and AS 160.

Two experiments, one in Tara TE (AS128) and the other in Dilli TE (AS160) were laid out during 1974 and 1977 respectively. The results for the year 1982 are presented in table 2.07.

Table 2.07. *Effect of rejuvenation on yield (1982)*

Treatments	Yield (KMTH) AS128(LP)	AS160(LP)
T1 – No rejuvenation (control)	1850	1717
T2 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one	2167	1789
T3 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one, also interplant to make into hedge.	2234	2279
T4 – Prune in July/August and infill in the autumn as in T2.	2183	2348
T5 Prune in July/August and infill in the autumn as in T3.	2165	2258
CD(P=.05) between two treatments mean	169	422
CV%	2.87	7.32

At Tara TE (AS128) all rejuvenation treatments increased the yield over control, but there was no significant difference amongst the different treatments. However, pruning in cold weather and interplanting gave the highest yield.

In Dilli TE (AS160) all the rejuvenation treatments except T2 increased yield significantly over control.

(ii) **Cachar (Assam): C47**

This experiment at Isabheel TE (C47) was laidout in 1974. The yield data for the year 1982 are presented in table 2.08.

Table 2.08. *Effect of rejuvenation on yield (1982).*

Treatments	Yield (KMTH) LP
T1 – No rejuvenation (control)	886
T2 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one.	1184
T3 – Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one, also interplant to make into hedge.	1514
T4 – Prune in July/August and infill in the autumn as in T2.	1084
T5 – Prune in July/August and infill in the autumn as in T3.	1289
CD(P=.05) between two treatment means	210
CV%	6.36

In the Isabheel experiment (C47), cold weather prune and interplanting (T3) significantly increased the yield over all other treatments. No significant difference in yield was observed amongst the other rejuvenation treatments.

2. Bringing up of Young Tea

An experiment in Arcuttipore TE (C51) in Cachar was started in 1977 to find out the most suitable method of bringing up of young tea.

The results for the year 1982 are presented in the following table.

Table 2.09. *Effect of different methods of bringing up of young tea on yield (1982)*

Treatments	Yield KMTH 1982(DS)
T1 – Cut across at 35cm from the ground. Centre out between 10-15cm leaving 2-3 side laterals. Pluck at 50cm frame forming prune after 12-18 months then follow step up plucking.	3287
T2 – Pegging - follow step up plucking initiating from 40-45cm. Cut across at 35-40cm after one full season and light centre clean out. Then follow step up plucking.	3.81
T3 – Thumb - nail pruning after 10-12 weeks. Tip at 55cm and step up for two years and then cut across at 35-40cm.	3.00
T4 – Centre out and followed by ring pegging. Tip at 50cm and step up.	3316
CD between two treatment means (P=.05)	NS
CV%	3.37

The treatment consisting of pegging followed by step up plucking initiating from 40-45cm and cut across at 35-40cm after one full season and light centre clean out and then step up plucking (T2) continued to give higher crop over other treatments. However, the difference amongst various treatments were found to be statistically non-significant in 1982, which was a deep skiffed year.

3. Plucking round

To study the effect of plucking round on yield, two experiments were laidout in 1978 at Nahortalli TE (AS170 and AS171) in South Bank, Assam.

The yield data for both the experiments are presented in table 2.10.

Table 2.10 *Effect of plucking round on yield (1982)*

Treatments	Yield KMTH	
	AS170(LP)	AS171(UP)
T1 = 5 days round	1562	3369
T2 = 6 " "	1708	3718
T3 = 7 " "	1622	3471
T4 = 8 " "	1691	3862
T5 = 9 " "	1760	3743
T6 = 10 " "	1643	3970
T7 = 11 " "	2084	4000
T8 = 12 " "	1978	4000
T9 = 13 " "	2422	4370
CD(P=.05) between two treatment means	49	209
CV%	1.55	3.15

Yield obtained from 13 days plucking rounds was significantly higher than the other treatments in both pruned (AS170) and unpruned (AS171) tea.

A near linear relationship between yield and plucking rounds was observed, the more the time interval between pluckings, the more was the yield.

4. Times of Pruning/Skiffing

(i) South Bank experiment

Two experiments, one in Daimukhia TE (AS173, AS174, AS175) and the other in Hattikhuli TE (AS 176, AS177, AS178), were laid out in 1980 to study the effect of different times of pruning and skiffing from Mid-October to Mid-February in the LP-DS-MS cycle.

The results for the year 1982 are presented in the table 2.11.

Table 2.11. *Effects of times of pruning and skiffng on yield (1982)*

Treatments	Yield KMTH					
	AS 173 (DS)	174 (MS)	175 (LP)	176 (DS)	177 (MS)	178 (LP)
T1=Mid October	1998	2289	1791	3335	3293	2612
T2=Mid November	1789	1994	1802	3234	3222	2915
T3=Mid December	2012	2030	1969	3084	3258	2945
T4=Mid January	2165	2325	2030	3314	3214	2840
T5=Early February	2109	2334	2034	3228	3120	2680
T6=Mid February	2173	2278	2063	3141	3164	2688
C.D.(P=.05) between two treatments means	116	122	127	148	NS	101
CV%	4.80	4.64	5.47	3.78	3.65	3.01

At Daimukhia T.E. pruning or skiffing between mid-January to mid-February (T4, T5 and T6) produced significantly higher crop than mid-November or mid-December pruning/skiffing. Early medium skiffing (mid-October, T1) also produced significantly higher crop than mid-November skiffing (T2) possibly due to formation of the plucking table within the season. At Hattikhuli TE on the other hand, there was no significant difference in crop between the various times of skiffing, although late skiffing, beyond end-January (T5 and T6) tended to depress yield. In this trial, mid-December deep skiffing (T3) significantly depressed crop compared to mid-October (T1), mid-November (T2) mid-January (T4) and early February (T5) skiffings. Light pruning in mid-December (T3) produced significantly higher crop over all other treatments except for mid-November pruning (T2) which closely followed mid-December pruning.

(ii) North Bank experiment

The yield for the year 1982 of the experiment conducted at Dhekiajullie TE in North Bank (AN182, AN183, AN184) are presented in the following table. 2.12

Table 2.12. *Effect of times of pruning and skiffing on yield (1982)*

Treatments	Yield KMTH		
	AN182(DS)	AN183(MS)	AN184(LP)
T1 = Mid-October	2205	1656	1493
T2 = Mid-November	2320	1885	2023
T3 = Mid-December	2328	2088	2026
T4 = Mid-January	2409	2095	2128
T5 = Early-February	2639	2001	1884
T6 = Mid-February	2579	1924	1853
CD(P=.05)between two treatment means	234	182	184
CV%	8.17	7.80	8.14

In the North Bank trial, delaying of skiffing tended to increase crop and maximum crop was obtaining when skiffing was done after mid-December. In the Deep skiffed year maximum crop was obtained by skiffing in mid-January to mid-February (T4, T5 and T6). In case of medium skiff however, maximum crop was obtained by skiffing between mid-December to mid-February (T3, T4 , T5 and T6) the difference with other treatments being statistically significant. Light pruning between mid-November to mid-January (T2, T3 and T4) produced higher crop compared to other treatments and pruning in mid-January (T4) produced the highest crop which was also significantly different than the other three treatments (T1, T5 and T6).

(iii) Cachar experiment

The yield data for the year 1982 of the experiment conducted at Arcuttipore TE in Cachar (C58, C59, C60) are presented in table 2.13.

Table 2.13. *Effect of times of pruning and skiffing on yield (1982)*

Treatments	Yield KMTH		
	C58(DS)	C59(MS)	C60(LP)
T1 = Mid-October	2035	2121	1450
T2 = Mid-November	2285	2336	1731
T3 = Mid-December	2438	2409	1790
T4 = Mid-January	2462	2349	1731
T5 = Early-February	2263	2330	1703
T6 = Mid-February	2285	2443	1692
CD(P=.05) between two treatments means	152	158	92
CV%	5.58	5.71	4.61

The data from the trial indicates that under Cachar condition skiffing or pruning from mid-November can be of advantage. Higher crop was produced either by skiffing or pruning in mid-December (T3) or mid-January (T4) except under medium skiff when maximum crop was obtained by skiffing in mid-February (T6). In case of deep skiff, mid-December or mid-January skiffing produced significantly higher crop compared to all other treatments and there was practically no difference between these two times of skiffing. Under medium skiff or light prune, the crop did not differ significantly amongst the various treatments except for the mid-October skiffing or pruning treatment (T1).

5. **Biclonal Stock Trial**

This trial (AN172) was initiated in 1978 at the North Bank (Thakurbari) to compare the yields of different stocks. The yield for the year 1982 are given in table 2.14.

Table 2.14. *Yield of different Biclonal Stocks (1982).*

Variety	Yield KMTH (UP)
T1 = Stock 379	1603
T2 = " 449	1895
T3 = " 450	1803
T4 = " 460	2238
T5 = " 461	2145
T6 = " 462	2108
T7 = " 463	2158
T8 = " 464	2110
T9 = Bari No.7	1778
T10 = TV 1	2150
CD(P=.05) for TR means	NS
CV%	13.14

In 1982, the highest yield was obtained from stock 460 followed by stock 468, stock 461, stock 464 and stock 462 whereas stock 397 gave the lowest yield. There was, however, no statistical difference in yields amongst the different tested seed stocks or the control (i.e. TV1). In the 4th year, the yield of stocks 463,461,464 and 462 were almost similar and were comparable to that obtained from TV1. Stock 460 produced approximately 100 Kg more yield compared to these four stocks of the control.

Highlights

In an experiment with 3 to 4 years old tea, TV 1 significantly out-yielded TV11 and TV 18 and 75 kg N/ha was found to be as good as 150 kg N/ha. N-serve application did not influence the crop yield significantly. The damaging effect of higher dose of nitrogen was observed to be irrepairable even after seven years of cessation/reduction. Zinc spray boosted the phosphate uptake resulting in higher phosphate content in both two and a bud and third leaf. The bio-efficacy tests of two new herbicides viz. 'Basta' (Hoechst)and DOWCO-453 (Dow Chemicals) have shown promising results in controlling grassy weeds.

Nitrogen

A factorial experiment B 5·1, was started in 1961 with four levels of nitrogen (0, 50, 100 and 150 kg N/ha), two levels each of phosphate (0 and 25 kg P_2O_5 /ha) and potash (0 and 100 kg K_2O/ha) on Tingamira *jat* of tea under shaded and unshaded conditions. As the shade became uneven, the shade trees were uprooted in 1980 and replanted with *Indigofera* shade trees in 1981. The results of the unshaded part are presented in table 3·01.

Table 3.01. *Effect of different levels of nitrogen on the yield of unshaded Tingamira jat tea (KMTH)*

Nitrogen levels (kg/ha)	1978 L.P.	1979 D.S.	1980 U.P.	1981 L.P.	1982 D.S.
0	919	845	794	899	947
50	1341	1272	1193	1421	1522
100	1143	1183	1234	1294	1332
150	760	872	974	950	916
CD at 5% level	89	96	97	89	110
C.V.%	12	13	13	11	13

Significantly more yield was given by 50 kg nitrogen per hectare in LP and DS years over no nitrogen, 100 kg and 150 kg nitrogen per hectare except in 1979. In unpruned years the yield at 50 kg nitrogen was slightly less than at 100 kg nitrogen per hectare but the difference in yield between the two levels was not significant. Adverse effect of 150 kg N/ha was prominent in any type of pruning.

Though the shade effect of newly planted shade trees has not been ready yet, the results of 1982 are presented in table 3.02.

Table 3.02. *Effect of different levels of nitrogen on the yield of shaded Tingamira jat tea (KMTH)*

Nitrogen levels (kg/ha)	1982 D.S.
0	1305
50	1479
100	1265
150	846
CD at 5% level	125
C.V. %	14.4

50 kg nitrogen per hectare significantly increased the yield over all other levels including no nitrogen. 150 kg N/ha reduced the yield by 30% when compared with no nitrogen plots. Though there was no significant difference between 100 kg and no nitrogen levels slight reduction in 100 kg level was observed.

Experiment B 104 was initiated in 1957 to study effects of three levels of nitrogen (90, 135 and 180 kg/ha) on two *jats* (Betjan and Gaurishankar) of tea planted at five different spacings. During the initial period upto 1968 the yield differences between the nitrogen levels were not significant. As the tea became older the yield declined significantly at highest dose of nitrogen (180 kg/ha) as compared with 90 and 135 kg doses. It was also observed that 135 kg gave significantly less yield than 90 kg in 1974, 1978, 1979 and 1980 (Table 3.03).

Table 3.03. *Effect of three levels of nitrogen on yield of Betjan and Gaurishankar jat tea (KMTH)*

Nitrogen levels (kg/ha)	1977 L.P.	1978 D.S.	1979 U.P.	1980 L.P.	1981 D.S.	1982 U.P.
90	1289	1504	1432	1336	1697	1591
135	1234	1412	1333	1243	1604	1511
180	1133	1280	1210	1074	1442	1398
CD at 5% level	62	74	80	73	105	98
C.V. %	11.4	11.1	11.4	7.8	14.9	14.6

Experiment B 20/1 was planted in 1979 with clones TV 1, TV 11 and TV 18 under *Indigofera* shade to study the effects of three levels of nitrogen (0, 75 and 150 kg/ha), three levels of phosphate (0, 25 and 50 kg/ha) and three levels of potash (0, 75 and 150 kg/ha) on these clones. Experimental results were available from 1981 and presented in table 3.04.

Table 3.04. *Effect of nitrogen at three different levels on the yield of three different clones (KMTH)*

Nitrogen levels (kg/ha)	1981 U.P.	1982 L.P.
0	1222	8[illegible]5
75	1524	1136
150	1557	1107
CD at 5% level	93	82
Clones		
TV 1	1632	1157
TV 11	1190	935
TV 18	1481	1016
CD at 5% level	93	82
C.V. %	16.9	20.5

In both the years the main effect of nitrogen and clones were significant, 75 kg/ha was as good as 150 kg/ha nitrogen and both levels yielded significantly more than no nitrogen plots. TV 1 significantly outyielded the other two clones. In 1981 TV 18 was significantly superior to TV 11 but in 1982 the yield difference between the two clones were not significant which may

be the effect of light prune. Other factors and their interactions had not shown any significant effect.

The experiment T/10 has been continuing since 1979 to study the effect of nitrification inhibitor N-serve on yield of clonal tea.

Main plot treatments contained four levels of nitrogen (0, 100, 200 and 300 kg/ha) and in the three sub-plots three levels N-serve (0,1 and 3%) was applied.

In 1981 treatments were not applied.

Table 3.05. *Effect of nitrogen and N-serve on yield of tea (KMTH)*

Treatments	1979 U.P.	1980 U.P.	1981 L.P.	1982 D.S.
N_0 (control)	2402	1649	1433	1536
N_{100} kg/ha	2874	2099	1497	1903
N_{200} kg/ha	2819	2146	1546	1995
N_{300} kg/ha	2848	2448	1680	2071
CD at 5% level	155	234	N.S.	239
C.V. %	4.9	9.7	14.0	11.1
0% N-serve	2717	2105	1540	1890
1% N-serve	2761	2144	1552	1893
3% N-serve	2730	2007	1526	1847
CD at 5% level	N.S.	N.S.	N.S.	N.S.
C.V. %	5.8	7.2	5.9	6.9

In all the three years, 1979, 1980 and 1982 when nitrogen and N-serve were applied the yield was increased significantly over no nitrogen plots. The yield difference between 100 kg, 200 kg and 300 kg nitrogen was not significant in the first unpruned year, 1979 and deep skiffed year 1982 but in 1980, the second unpruned year, 300 kg level significantly increased the yield over 100 kg and 200 kg nitrogen. In 1981, when the treatments (nitrogen and N-serve) were not applied the yield difference was also not significant though the yield with higher nitrogen level plots was progressively increased. Effect of N-serve on crop yield or response to nitrogen was not observed in any of the years.

Experiment B 113/1 was initiated in 1965 to study the effect of single and split application of 90 and 135 kg nitrogen per hectare on Khorijan *jat* of tea planted in 1960. Since no effect of the treatments were observed the experiment was stopped in 1975. In 1976, these treatments were modified with a view to study the effect of cessation and reduction of nitrogen doses on yield. Nitrogen dose 135 kg/ha which was applied in the previous experiment was changed to 135, 90, 45 and 0 kg/ha; the other dose 90 kg/ha was changed to 90, 45 and 0 kg/ha. The treatment effects are presented in table 3.06.

Table 3.06. *Effect of cessation/reduction of nitrogen on yield of tea (KMTH)*

Treatments Old	New	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.	1981 U.P.	1982 L.P.
90	— 90	1665	1964	1920	1502	1788	1891	1728
90	— 45	1552	1770	1801	1411	1585	1682	1605
90	— 0	1478	1571	1552	1332	1510	1445	1551
135	— 135	1538	1909	1860	1220	1549	1681	1307
135	— 90	1530	1754	1714	1349	1572	1644	1523
135	— 45	1530	1693	1670	1330	1580	1628	1584
135	— 0	1522	1553	1488	1308	1532	1490	1596
CD at 5% level		N.S.	204	223	N.S.	N.S.	186	N.S.
C.V. %		4.5	6.6	7.3	6.6	7.2	6.2	9.8

Effect of reduction/cessation of nitrogen was prominent from the first year (1976) in 90 kg series, while in 135 kg series significant effect was observed from the second year (1977) of experimentation. In the second and third years yield reduction was significant in both 90 kg and 135 kg series. When 90 kg application was stopped significant reduction in yield was observed in comparison with 90 kg continuous application. In

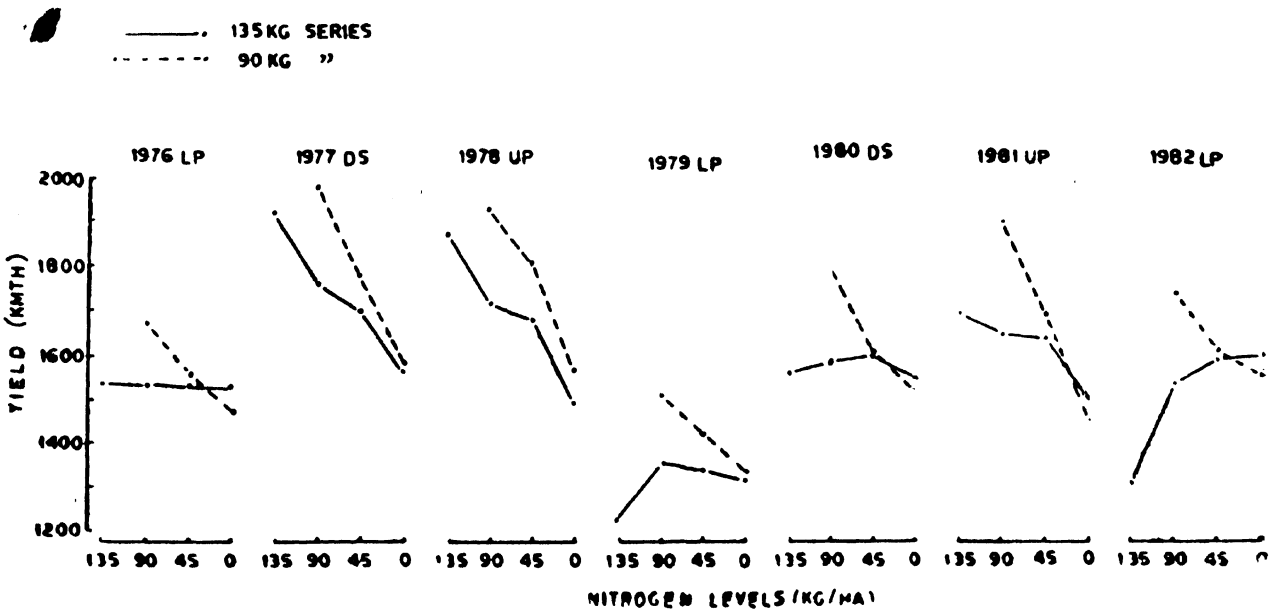


Fig 1. Effect of cessation/reduction of nitrogen levels on yield of tea

135 kg series also the yield reduced significantly when it was reduced to 45 and 0 kg N/ha. The yield reduction due to the reduction of nitrogen dose from 90 to 45 and 135 to 90 kg was not significant as compared to the continuous application of the former doses. In the second and third LP years (1979 and 1982) the yield differences were not significant but 135 kg continuous application resulted in the lowest and 90 kg continuous application the highest yield. In 1981, an unpruned year, the treatment receiving 90 kg N/ha recorded the highest yield which was significantly superior to the rest of the treatments. Damage done by the application of 135 kg N/ha appears to be irrepairable even after reduction of fertilizer for seven successive years.

It appears from the findings that under the situation 90 kg ha was the optimum dose. Yield level at 135 kg/ha always remained less than that of 90 kg/ha. Reduction and cessation of nitrogen level in 90 kg series reduced the crop yield from the beginning in any type of pruning, while in 135 kg series yield reduction was not prominent from the second light pruned year (1979) on reduction or cessation of nitrogen level. Fig. 1.

Phosphate

The factorial experiment B 105 was started in 1960 on clone TV 2 to study the response of four levels of phosphate and potash each at 0, 45, 90 and 180 kg/ha with a constant dose of 90 kg nitrogen/ha. The nitrogen rate was increased to 135 kg/ha since 1972. The results are presented in table 3.07.

Table 3.07. *Effect of phosphate and potash on yield of tea (KMTH)*

Phosphate	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.	1981 U.P.	1982 L.P.
0	1022	1348	1440	1211	1039	1241	1088
45	1231	1631	1657	1425	1418	1679	1464
90	1410	1646	1648	1480	1532	1694	1508
180	1446	1599	1591	1383	1533	1756	1484
CD at 5% level	139	175	165	178	196	217	234
Potash							
0	1048	1218	1234	1053	1030	1148	984
45	1293	1525	1585	1380	1382	1510	1294
90	1349	1687	1709	1486	1499	1756	1568
180	1420	1793	1808	1580	1609	1955	1699
CD at 5% level	139	175	165	178	196	217	234
C.V. %	15.3	15.8	14.6	18.2	19.9	19.1	23.7

In the initial years (1962-69) phosphate application had no beneficial effect. The lack of response may be due to available phosphorous present in the soil that was sufficient for the requirement of the young bushes. In 1970, the phosphate response was significant for the first time where the highest dose of 180 kg/ha gave significantly less yield than 0, 45 and 90 kg/ha and the difference between the latter three doses was not significant. In 1974, 90 kg/ha increased the yield significantly over no phosphate.

Since 1976, significant response to phosphate application had been continuing over no phosphate. The beneficial effect was in favour of 45 and 90 kg/ha.

The experiment B 23/3 has been continuing since 1973 on Tingamira *jat* of tea under shade planted in 1961, to study whether the yield response to phosphate application is influenced by Guatemala mulch and control of weeds by manual and chemical means. The results are presented in table 3.08.

Table 3.08. *Effect of phosphate, mulch and weed control on yield of tea (KMTH)*

Treatments	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.	1981 U.P.	1982 L.P.
Phosphate kg/ha							
0	1623	1890	1920	1428	1820	2057	2097
50	1605	1843	1873	1448	1805	2080	2047
100	1588	1852	1951	1473	1861	2190	2061
150	1634	1901	1950	1414	1854	2105	2034
200	1661	1907	1971	1478	1872	2134	2027
CD at 5% level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. %	6.8	12.7	8.3	12.4	12.3	10 0	12.8
Mulch							
No Mulch	1592	1800	1855	1403	1783	2035	2059
Guatemala Mulch	1652	1957	2011	1489	1902	2191	2097
CD at 5% level	56	63	77	46	85	96	N.S.
C.V. %	7.6	7.4	8.9	7.1	10.3	10.0	11.6
Weed Control							
Cheeling	1584	1823	1915	1424	1796	2089	2003
Herbicide	1660	1934	1951	1472	1889	2137	2103
CD at 5% level	56	63	N.S.	46	85	N.S.	N.S.
C.V. %	7.6	7.4	8.9	7.1	10.3	10.0	11.6

It was observed that during the whole experimentation period phosphate had no effective response on the yield of tea. Mulching with Guatemala grass increased the yield significantly over no mulch. Chemical weed control, when compared with cheeling, increased the yield significantly except in unpruned years. In 1982, neither mulch nor weed control had any effect on yield which may be the effect of zinc spray. Mulch and weed control interaction was not significant in any year except in 1976, indicating that chemical weed control without mulch was as good as mulch with cheeling and mulch with chemical control of weeds. They were significantly superior to cheeling without mulch.

Zinc was sprayed in 1981 and 1982 to study if phosphate uptake of leaves was enhanced by zinc spray (Table 3.09). In both the years the yield increased as compared to the yield of corresponding years receiving similar pruning operations. Fig. 2 represents a comparative study of yield at different levels of P_2O_5 in two light prune years 1982 and 1976 with and without zinc spray respectively.

It appears from the table that foliar application of zinc has two fold effect on tea. It helps in increasing phosphate content in both two and a bud and third

leaf, secondly the higher is the dose of applied phosphate more is the uptake of P_2O_5. May be that zinc removes the limit (s) of phosphate uptake present in the high phosphate application (table 3.09).

Table 3.09. *Effect of foliar application of zinc on phosphate uptake (data of 1982 expressed as ppm P_2O_5 on dry weight basis).*

	Two and A Bud				Third leaf		
P \ Zn	+ Zinc	- Zinc	Mean	P \ Zn	+ Zinc	-Zinc	Mean
0	8057	8026	8042	0	6369	6346	6358
50	8323	8251	8287	50	6572	6550	6561
100	8414	8472	8443	100	6729	6657	6693
150	8630	8360	8495	150	6799	6719	6759
200	8718	8418	8568	200	7009	6449	6729
Mean	8429	8305		Mean	6696	6544	
CD between two P means = 115				CD between two P means = 154			
between zinc mean = 73				between zinc mean = 128			
between interaction = 162				between interaction = 286			

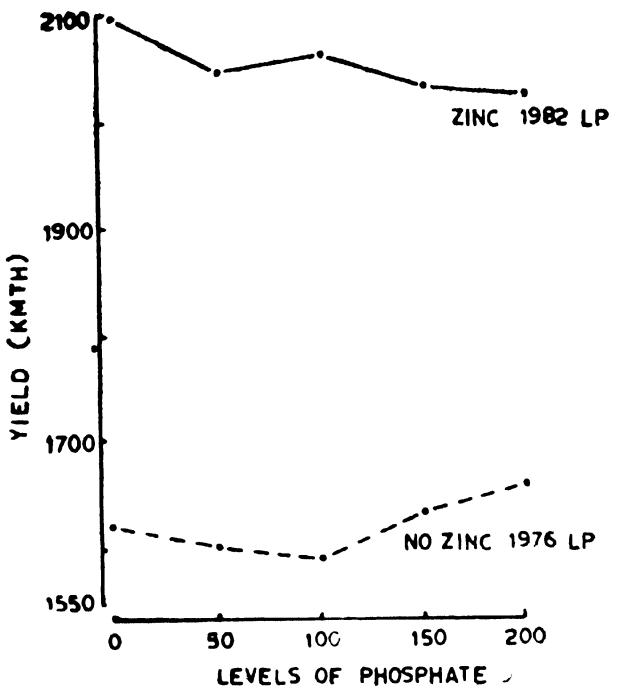


Fig 2. Effect of zinc spray on yield of tea at different levels of phosphate in two light pruned years.

Potash

Response to potash application over no potash was significant in experiments B 5.1. and B 105.

On unshaded tea, experiment B 5.1, N × K interaction had shown significant effect in all the years from 1972. The significant effect of potash application as against no potash was observed when 100 kg K_2O/ha was applied with 50, 100 and 150 kg nitrogen per hectare. 100 kg K_2O/ha when applied with 50 and 100 kg N/ha the difference in yield was not significant but both these combinations yielded significantly more than 100 kg K_2O with 150 kg nitrogen per hectare. The effect of potash application without nitrogen on the yield of tea was not promising (table 3.10).

In the other experiment B 105, a shaded TV 2 clone, potash application always yielded significantly more than no potash (table 3.11).

Significant increase in yield between 90 kg and 45 kg application of potash was visible only in 1981 and 1982 i.e. after 20 years of continuous application

Table 3.11. *Effect of potash on the yield of tea (KMTH)*

K_2O/ha	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.	1980 D.S.	1981 U.P.	1982 L.P.
0	1048	1218	1234	1053	1030	1148	984
45	1293	1525	1585	1380	1382	1510	1294
90	1349	1687	1709	1486	1499	1756	1568
180	1420	1793	1808	1580	1609	1955	1699
CD at 5% level	139	175	165	178	196	217	234
C.V. %	15.3	15.8	14.6	18.2	19.9	19.1	23.7

of potash, indicating that 90 kg K_2O/ha significantly increased the yield over 45 kg K_2O/ha application. Till 1980 the differences between the two doses were not significant. There was also no significant difference in yield between 90 kg and 180 kg K_2O/ha. Application of 180 kg K_2O/ha gave significantly more yield than 45 kg K_2O/ha in almost all the years since the beginning of the experiment.

Micronutrients

Two trials on micronutrients were conducted. The first trial T/2 was initiated in 1978 to study the response of different micronutrients and their combinations on the yield of Betjan *jat* of tea planted in 1957. The micronutrients were zinc, boron, magnesium, manganese and molybdenum alone and in various combinations. The treatment differences were not significant upto 1980. In the light skiffed year 1981, mixture of zinc sulphate + magnesium sulphate + manganese sulphate at 5 kg each round and moly-

Table 3.10. *Nitrogen and potash interaction on yield (KMTH)*

kg/ha	1978 (LP)		1979 (DS)		1980 (UP)		1981 (LP)		1982 (DS)	
N \ K_2O	0	100	0	100	0	100	0	100	0	100
0	982	856	872	817	742	846	898	900	988	906
50	1193	1489	1130	1414	1023	1363	1302	1540	1395	1648
100	900	1386	963	1402	1026	1443	1019	1569	1079	1585
150	499	1020	606	1137	649	1299	640	1260	586	1246
CD at 5% level	126		136		137		126		155	
C.V. %	12.0		13.0		13.0		11.0		13.0	

bdic acid at 10 g/round when sprayed four rounds was giving the highest yield which is also significant over the control. Zinc or molybdic acid or manganese alone was as good as the above mixture. In 1982 also the same combination was giving the highest yield followed by zinc, manganese and molybdic acid alone but these treatments were not significantly superior to control. Boric acid alone was giving significantly less yield than control.

The other trial T/3 was conducted since 1980 to study the effect of six different commercial formulations of micronutrients on yield of JTCL mixed clone planted in 1957. The treatments are: 1. Chelated zinc, 2. Zinc sulphate, 3. Tracel 2, 4. Multiplex, 5. M.I. Food, 6. Planton Green, 7. Water spray, 8. Control.

The treatment differences were significant in 1980 and 1982, deep skiff and light prune years respectively. In both the years M.I. Food produced the highest yield and significant over control and water spray. In 1982 this treatment gave significantly more yield than Tracel 2 also. With the second highest yield Planton Green was significantly superior to control and water spray in 1980 and water spray and Tracel 2 in 1982. The treatment differences were not significant in the light skiff year 1981. However, M.I. Food increased the yield by 88 kg/ha over control.

Irrigation

A single repeat trial T/1 was initiated in 1977 in a section of mixed clones planted in 1973 to study the effect of drip irrigation in tea. The treatments were: 1. Drip irrigation, 2. Drip irrigation with dissolved fertiliser and 3. Control (no irrigation). 100 kg nitrogen and potash per hectare were applied broadcast to treatments 1 and 3 while treatment 2 received the same quantity of fertiliser through irrigation water. The yield increase or decrease from irrigation treatments over no irrigation are presented in table 3.12 below.

Table 3.12. *Percent yield increase or decrease over no irrigation.*

Treatments	1978 U.P.	1979 U.P.	1980 L.P.	1981 U.P.	1982 U.P.
Irrigation alone	14.6	43.7	7.4	12.2	23.0
Irrigation with fertiliser	14.8	25.8	4.7	-2.1	-14.4

Response to irrigation varied from year to year. This may be related to distribution of rainfall during October-April period (table 3.15). In the irrigation treatment the yield was more than control in every year. It was also observed that in the second unpruned years 1979 and 1982 the yield increase was two to three times more than first unpruned years 1978 and 1981. Surprisingly when fertiliser was applied through irrigation water the yield came down below the control treatment from the fourth year.

Table 3.13. *Effect of sprinkler irrigation on the yield of tea (KMTH)*

	Treatments	1979 (UP)		1980 (UP)		1981 (LP)		1982 (DS)	
		Yield	% increase over control	Yield	% increase over control	Yield	% increase over control	Yield	% increase over control
1.	Control (No irrigation)	1518		1243		1029		1246	
2.	Irrigation at 25% depletion in root zone.	1890	24.5	1284	3.3	1078	4.8	1433	15.0
3.	Irrigation at 50% depletion in root zone.	1870	23.2	1265	1.8	1083	5.2	1346	8.0
4.	Replenishment of water on the basis of open pan deficit (100% ET).	1872	23.3	1390	11.8	1129	9.7	1573	26.2
5.	Irrigation at 5 cm/month from December to April.	1868	23.1	1374	10.5	1145	11.3	1613	29.4
6.	Irrigation on the basis of statistical findings.	1758*	15.8	1389	11.7	1144	11.2	1588	27.5
	C.D. at 5% level		178		N.S.		N.S.		133
	C.V. %		5.4		6.1		4.1		5.0

*In 1979, treatment 6 could not be irrigated as scheduled from November 1978 and was irrigated from January 1979.

Table 3.14. *Details of irrigation applied in different treatments*

Tr. No.	Irrigation period				No. of irrigation				Amount of water (cm)			
	1978-'79	1979-'80	1980-'81	1981-'82	1978-'79	1979-'80	1980-'81	1981-'82	1978-'79	1979-'80	1980-'81	1981-'82
1.	—	—	—	—	—	—	—	—	—	—	—	—
2.	26.2.79 to 21.4.79	—	5.1.81 to 27.2.81	22.1.82 to 19.3.82	3	—	3	3	13.50	—	13.50	13.50
3.	27.1.79 to 23.4.79	—	—	—	5	—	—	—	45.00	—	—	—
4.	3.1.79 to 2.5.79	31.12.79	1.1.81 to 3.3.81	1.12.81 to 1.4.82	5	1	2	5	17.00	0.64	3.96	12.99
5.	21.12.78 to 4.4.79	13.12.79 to 11.4.80	27.12.80 to 21.4.81	9.12.81 to 12.4.82	5	5	5	5	25.00	25.00	25.00	25.00
6.	2.1.79 to 3.5.79	15.11.79 to 16.4.80	31.12.80 to 30.5.81	16.11.81 to 30.4.82	9	7	6	11	38.60	19.89	20.58	25.78

The second trial with sprinkler system of irrigation T/9 was started in 1979 on shaded Khorijan *jat* of tea to determine the effect of irrigation. The results of the experiment and the details of irrigation treatments are presented in tables 3.13. and 3.14 respectively.

In 1979 all the irrigation treatments yielded significantly more than control and the difference between the irrigation treatments were not significant. Compared to other treatments, irrigation on the basis of statistical findings, T_6, gave 7-8% less yield. This difference in yield may be due to that irrigation could not be given in this treatment before January, 1979 as against November, 1978. Further table 3.14 had shown that December, 1978 to March, 1979 was very dry as compared to that period of other years.

During 1980, the second unpruned year when the rainfall distribution was good the treatment differences were not significant. Irrigation at 25% and 50% depletion in the root zone needed no irrigation water due to rainfall and yielded almost equal to control treatment. On the contrary the other three treatments, 100% ET loss, 5 cm each month from December to April and the one that based on statistical findings increased the yield by 11.8, 10.5 and 11.7 per cent respectivly over control.

In 1981, a light pruned year, the effect of irrigation was not significant. This year 50% depletion in root zone needed no irrigation. Gain in crop over control in 25 and 50% depletion in root zone was much less as compared to 100% ET loss, 5 cm/month from December to April and based on statistical findings.

In the deep skiffed year 1982, 100% ET loss, 5 cm/month from December to April and based on statistical findings the yield was significantly more than control, 25 and 50% depletion in root zone. Crop gain from these three treatments over control was 26.2, 29.4 and 27.5% respectively.

Table 3.15. *Monthly rainfall (mm) from October to April as recorded at Tocklai*

Months	1977-78	1978-79	1979-80	1980-81	1981-82
October	181.3	39.0	193.2	135.9	94.8
November	19.5	73.0	44.0	1.1	5.0
December	18.7	0.0	22.3	0.0	25.9
January	4.7	6.5	30.8	39.3	0.0
February	12.7	0.7	56.7	27.4	39.1
March	62.4	13.1	86.2	90.9	18.0
April	43.1	72.8	260.8	171.5	230.1
Total	342.4	205.1	694.0	466.1	412.9

Plucking

Plucking standard experiment B 112.1/1 was continuing from 1976 on shaded Khorijan and Tingamira *jats* of tea planted in 1960. The object was to make a comparative study of standard and black plucking throughout the year and in early, main and late season. The treatment differences were significant in the first unpruned year 1978 and deep skiffed year 1979. In all the years during the experimentation whether the result was significant or not it indicated that black plucking either throughout the year or in the main season reduced the crop when compared with black plucking either in early or late season (table 3.16).

Table 3.16. *Effect of different combinations of standard (St) and black (Bl) plucking, at different periods of the year, on the yield of tea (KMTH)*

Treatments	1981(LP) Season Early	Main	Late	Total	1982(DS) Season Early	Main	Late	Total
Bl-Bl-Bl	44	1220	437	1701	155	1155	480	1790
Bl-Bl-St	38	1184	508	1730	143	1161	546	1850
Bl-St-St-	43	1331	433	1807	176	1425	485	2086
Bl-St-Bl	33	1331	381	1745	156	1380	446	1982
St-St-St	39	1377	436	1852	147	1384	498	2029
St-St-Bl	44	1352	389	1785	167	1386	473	2026
St-Bl-Bl	47	1236	430	1713	180	1188	498	1866
St-Bl-St	36	1217	511	1764	150	1224	540	1914
CD at 5% level				N.S.				N.S.
C.V. %				8.5				9.4

Another experiment T/4 was initiated in 1978 on shaded clonal tea (JTCL 340) planted in 1967 to study the effect of frequency of plucking on yield. The results are given in table 3.17.

Table 3.17. *Effect of frequency of plucking on yield (KMTH)*

Frequency of plucking	1978 D.S.	1979 U.P.	1980 L.P.	1981 D.S.	1982 U.P.
5 day	2390	3097	1891	2807	3730
7 day	2567	3615	2333	3325	4371
9 day	3063	3550	2567	3750	4017
11 day	2966	3598	2332	3515	3985
13 day	3473	3949	2676	4529	4362
CD at 5% level	233	240	261	235	408
C.V. %	5.2	4.4	7.2	4.2	6.5

Pluck at 13 day interval yielded significantly more than the rest of the intervals in 1978, 1979 and 1981. In the light pruned year 1980, 9 day was as good as 13 day interval but 5, 7 and 11 day interval gave significantly less yield than 13 day interval. In 1982, unpruned year 7 day interval was leading the other intervals though the difference between 7, 9, 11 and 13 day interval was not significant. 5 day, when compared with other intervals was giving significantly low yield in all the years except in 1982, where 5 day was as good as 9 day and 11 day interval. Upto 1981, 13 day was leading but in 1982, 7 day led all other intervals. This will require some more time to explain the reason.

Experiment T/5 started in 1978 on shaded clonal tea (CNM 33/52), planted in 1967 to study the effect of three plucking standards under three plucking systems on yield. The results are given in table 3.18.

In the deep skiffed and light pruned years 1978, 1980 and 1981, janam coarse and janam coarse with step up in July plucking gave significantly higher yield as compared to other plucking treatments. In the unpruned year 1979 janam coarse plucking yielded significantly more than the other treatments but in 1982

Table 3.18 *Effect of standard and system of plucking on the yield of tea (KMTH)*

Years	Janam			Fish leaf			Janam + Step up in July				
	Black	Std. leaving 1 + bud	Coarse leaving 2 + bud	Black	Std. leaving 1 + bud	Coarse leaving 2 + bud	Black	Std. leaving 1 + bud	Coarse leaving 2 + bud	CD at 5% level	C.V.%
1978 D.S.	1786	1997	2333	1885	1870	2063	1646	1820	2268	162	4.6
1979 U.P.	2723	2624	3212	2768	2766	2748	2417	2569	2865	166	3.5
1980 L.P.	1376	1549	1712	1625	1584	1523	1502	1498	1804	99	3.6
1981 D.S.	2182	2267	2896	2081	2548	2444	2168	2252	2989	212	5.1
1982 U.P	3003	3153	3154	2749	2796	2528	2705	2677	2796	232	4.7
Total	11070	11590	13307	11108	11564	11306	10438	10816	12722		

which was also an unpruned year, all the three standards of janam plucking were giving almost equal yield; further more janam standard and janam coarse plucking were giving significantly more yield than all the three standards of fish leaf and janam with step up plucking. Five years total yield had shown that janam coarse plucking produced highest yield followed by step up in July coarse plucking.

Long term yield trial on Tocklai Clones

A long term yield trial of 18 different released clones along with Betjan *jat* and Stock 450 (B40/1) was started in 1967 to study the performance of Tocklai released clones. Results are presented in table 3.19

Table 3.19. *Yield of different clones (KMTH)*

Clone	1978 L.P.	1979 D.S.	1980 U.P.	1981 L.P.	982 D.S.
TV 1	1791	1902	2140	2200	1941
TV 2	1769	1315	1694	1753	1701
TV 4	1850	2076	2181	2218	2231
TV 6	1104	1240	1564	1442	1404
TV 7	1471	1453	1490	1836	1486
TV 8	1588	1718	2200	2300	2062
TV 9	1907	1881	2059	2260	1978
TV 10	1864	1857	2410	2214	1823
TV 11	1983	1869	2327	237	1930
TV 12	1702	1835	1875	2052	1912
TV 13	1365	1524	1923	1759	1705
TV 14	2045	2074	2203	2238	1983
TV 15	1656	1899	2342	2271	2181
TV 16	2002	2078	2165	2356	2194
TV 17	1892	2075	2723	2516	2178
TV 18	1894	1940	2122	2429	2255
TV 19	2262	2453	2246	2527	2294
107/2	1892	2017	1985	2349	2267
Stock 450	1759	1808	1960	2249	2059
Betjan	1619	1681	1968	1896	1716
C. D. at 5% level	333	298	338	292	259
C.V.%	13.5	11.4	11.5	9.5	9.3

In the light pruned year 1978, TV 19 led and followed by TV 14 and TV 16. In the deep skiffed year 1979, highest yield was given by TV 19 and followed by TV 16, TV 4, TV 17 and TV 14. In the unpruned year 1980, TV 17 gave the highest yield, which was 400 kg more than its next highest yielders TV 15 and TV 11. In 1981 light pruned year TV 19 led and followed by TV 17 an TV 18. In deep skiffed year 1982, TV 19 gave the highest yield followed by 107/2, TV 18 and TV 4.

The results indicated that in the light pruned and deep skiffed years TV 19 and in unpruned years TV 17 gave the highest yield which had given ground for inferring that pruning operation had mutual action on type of clone.

WEED CONTROL

I. New Herbicides

Bio-efficacy tests on two new herbicides were carried out during the year. The 'Test II' results showed promising trends for both the herbicides.

a. *Basta:* "Basta" (Code name HOE 39866) a new contact, postemergence herbicide, proved to be very effective specially on grasses (table 3.20).

Table 3.20. *Effect of Basta on different grasses*

	% Control of weeds at different DAS*					
	Imperata cylindrica		*Ferns*		*Paspalum scrobiculatum*	
DAS	20	74	15	69	14	57
Basta 0.5 kg ai/ha	57	20	15	37	55	60
Basta 1.0 kg ai/ha	72	37	23	58	73	90
Mean	64	28	19	47	64	75

* Days after spraying

Two applications of Basta at one month's interval could control *Imperata cylindrica* upto an extent of 90% of green cover (table 3.21). In another nursery experiment it was observed that addition of either simazine or oxyfluorfen as tank mix to Basta, delayed regrowth of the weeds considerably (table 3.22). In a spraying experiment in young tea, where the herbicide was sprayed in directed, non-directed, and on top of the bush its deleterious effect was evident only when sprayed on the top of the tea bushes. This herbicide is to undergo large-scale tests prior to certification, next year.

Table 3.21. *Effect of two monthly application of Basta on I. cylindrica*

	% Control of weeds							
DAS	7	15	22	31	38	45	52	64
Basta 0.5 kg ai	45	58	67	83	90	90	88	82
Basta 1.0 kg ai	45	62	70	93	95	95	95	90
Mean	45	60	68	88	92	92	91	86

Table 3.22. *Effect of Basta alone and in combination with preemergence herbicide*

		% Control of weeds				
	DAS	12	34	55	69	87
Basta	1.0 kg ai	68	40	42	38	32
Basta + Simazine	1.0 kg ai + 2.0 kg ai	43	80	67	60	50
Basta + Oxyfluorfen	1.0 kg ai + 0.25 kg ai	65	87	63	60	53

DOWCO 453

This code herbicide is of translocated, post emergent type and very slow acting in behaviour. It showed reasonably good effect on grass weed control. However, compared to glyphosate, it was not very effective on *Paspalum conjugatum*, but it could control *Eleusine indica* very well (table 3.23).

Table 3.23. *Effect of DOWCO 453 on* P. conjugatum *and* E. indica

		% Control of weed			
		P. conjugatum		*E. indica*	
	DAS	15	64	14	74
DOWCO 453 + Polyglycol	0.5 kg ae + 0.25%	15	65	30	90
DOWCO 453 + Crop oil	0.5 kg ae + 1.0%	15	80	30	95
Glyphosate	0.8 kg ai	85	88	25	70

It was further observed that additive 'crop oil' improved its efficacy better than the other additive 'polyglycol'.

To observe its performance in a mixed weed situation, an experiment was conducted in a tea-area containing two grasses - *Digitaria* and *Saccharum* and a broadleaf weed *Borreria* - in an almost equal proportion (table 3.24). It was observed that when the original spray was followed by an application of 2,4-D amine two weeks later, DOWCO-453 performed as good as Glyphosate. However, there was very little need of 2,4-D after the application of Glyphosate. To look for possible harm to the tea bushes, the herbicide was sprayed in 'Directed', 'Non directed', and on 'top of the bush' manner in another experiment. No adverse effect to young tea was apparent, signifying it to be one of the safe herbicides for tea plants.

Table 3.24. *Effect of DOWCO-453 on a mixed weed stand*

	% Control of weeds		
DAS	15	30	55
Glyphosate 0.8 kg ai	47	65	67
Glyphosate 0.8 kg ai followed by 2,4-D Amine 0.5 kg ai	48	73	67
DOWCO 453 0.5 kg ae + Polyglycol 0.25% followed by 2,4-D 0.5 kg ai	17	58	70
DOWCO 453 0.5 kg ae + Crop oil 1.0% followed by 2,4-D 0.5 kg ai.	18	53	67

This herbicide is also awaiting Test III (large scale trials) next year

II. Enhancement of Efficacy of Herbicide

Oxyfluorfen - a new preemergent herbicide was recently recommended for use in tea plantations. To observe whether it could increase the activity of post emergent herbicides, an experiment was conducted in the weed nursery. Very little post emergence activity of oxyfluorfen was observed, but when it is mixed with glyphosate as tank-mix, the persistence of the latter's activity is increased by checking the regrowth of the weeds. However, the standard 'cocktail' of paraquat and diuron is more effective in controlling grasses than a tank mix of paraquat and oxyfluorfen (table 3.25).

Table 3.25. *Effect of oxyflourfen combinations on grasses*

		% Control of weeds			
	DAS	10	38	73	114
Oxyfluorfen	0.25 kg ai	0	0	0	0
Paraquat	0.4 kg ai	60	10	0	0
Paraquat + Diuron	0.4 kg ai + 1.0 kg ai	83	60	47	30
Glyphosate	0.8 kg ai	85	68	75	65
Paraquat + Oxyfluorfen	0.4 kg ai + 0.25 kg ai	68	33	13	10
Paraquat + Oxyfluorfen	0.4 kg ai + 0.5 kg ai	67	33	25	20
Glyphosate + Oxyfluorfen	0.8 kg ai + 0.25 kg ai	92	87	82	68
Glyphosate + Oxyfluorfen	0.8 kg ai + 0.5 kg ai	93	92	92	77

III. Control of Individual weeds

Imperata cylindrica: In earlier years, it was observed that *Imperata* could be controlled by five to six applications of paraquat at 10 to 15 days interval. To further confirm it, another experiment was conducted with application of paraquat 0.33% at different intervals. Again it was observed that application of paraquat every 10 days, 5 times, could control *Imperata* very effectively (table 3.26). After the first round, however, the interval between sprays can be increased.

Table 3.26. *Effect of variation in interval period in different rounds of paraquat application on the control of I. cylindrica*

Application time (days)						% Control of weeds		
1st round	2nd	3rd	4th	5th	6th	7 days	65 days after first round	134 days
0	10	20	30	40	50	80	96	95
0	10	20	40	60	80	80	92	92
0	10	20	50	80	110	80	90	90
0	15	30	45	60	75	80	66	85
0	15	30	55	80	105	80	63	90
0	15	30	60	90	120	80	72	77

IV. Check Tests

Herbicide samples sent from tea gardens was checked for quality and results reported. No substandard sample was obtained this year.

Three types of WFN nozzles were tested in the nozzle patternator and the spray delivery patterns determined. These were found to conform to the manufacturer's published standards.

V. Long term Use of Herbicides

An experiment was started in mature clonal tea in 1979 where different herbicides alone and in combination were used whenever required, to keep the plots weed free. The same herbicide was used in the same plots in every application. The yield of green leaf for all the years till date showed no significant difference due to treatment. In collaboration with Mycology and Entomology departments, the pest and disease incidence and soil microbial shift was monitored in the first two years, which was reported earlier. The residue of herbicide is pending investigation allowing time for the buildup in the soil.

Another experiment of similar type in mature tea, conducted since 1972, showed shift in dominance of weeds. However, the green leaf yield, here also failed to show significant difference.

Soils and Meteorology

Highlights

A. Plant nutrition

Undesirable accumulation of nitrate nitrogen in plucked shoot and soil solution due to long-term application of nitrogen at supra-optimal doses was considered to be a possible factor for yield depression and decay of feeder roots. Total nitrogen content of shoot and top soil were found to be highly correlated with yield for four consecutive years with a predictibility of 74 and 79% respectively. Besides another parameter, viz, nitrate reductase activity was found to be promising for finding out the nitrogen requirement of tea.

Feeder root production increased with long-term phosphate manuring @ 100 kg P_2O_5/ha. Shoot phosphate concentration (in the range 0.55–0.80% P_2O_5) was linearly correlated with yield in long-term experiment with a predictibility of 92%. Mixing rock phosphate and superphosphate at 50:50 ratio ensured optimum availability of added phosphate compared to superphosphate alone and the uptake of phosphate by young tea for a 3-year growth period under the same treatment was found to be linearly correlated with available phosphate content of soil.

Both potash content of shoot and available potash content of top soil were linearly correlated with yield at predictivity levels 87 and 82% respectively in long-term manurial experiment.

Boron uptake by young tea increased linearly upto 4 kg/ha boron application rates in soil. Depressive effect of calcium on boron uptake was remarkable at calcium application rates 20 and 40 kg Ca/ha respectively. Further available B content of soil was linearly correlated with B uptake at a predictivity level of 86%.

Vermiculite can be used with advantage as a soil conditioner, specially with coarse textured soils. A ratio of 50:50 vermiculite: soil (V/V) was found to be very promising for sandy soils, whereas 70:30 as soil: vermiculite was found better for sandy loam and silty clay loam soils in improvement of soil physical properties and growth of young tea.

B. Water Management

Designing of main outlet channels for various tea growing regions (Assam, Cachar and North Bengal) has been facilitated with the preparation of intensity - duration curves from long-term rainfall records, determination of run-off coefficients experimentally and experimental verification of curve No. 75 prepared by the U.S. Soil Conservation Service for directly obtaining peak design run-off and therefore peak discharge rates under varying rainfall conditions.

The maximum effective rainfall for recharging water table in monsoon was found to be 60 mm and the air-space estimated to be 10% by volume within 100 cm depth, i.e., depth of collector drain. These data formed the basis for computing spacings of field or secondary drains. Commonly adopted spacing and depth of secondary drains (13m spacing, 75 cm depth) could control water table effectively to the depth of drain only throughout monsoon. However to ensure against longer period of saturation of soils below drain bed level, the depth of secondary drains should be increased to atleast 90 cm. A highly significant head (h) and discharge rate (q) relationship of the secondary drains (spaced at 13 m and 75 cm deep) was obtained, suggesting quick recession of water table to drain depth.

Validity of pump drainage criteria of 12-13 mm/day (previously reported) was again confirmed from the current data.

Fluctuations of water table could be effectively controlled below 90 cm from ground level with secondary (buried pipe) drains at 23.0 m spacing and 1.5 m deep, as a consequence of which yield continued to be highest in this drainage system compared to all other spacings and depths included in these experiments.

A map has been prepared showing the probable evapotranspirational losses and therefore magnitude of drought that could be experienced in various tea growing regions of North East India.

NITROGEN USE EFFICIENCY BY USE OF STABLE ISOTOPES

N-15 assay of soil and plant samples from the same pot experiment reported earlier (Ann. Sci. Rept., 1981-82, p. 25) has shown little recovery of added fertiliser nitrogen and very low nitrogen use efficiency irrespective of the forms of nitrogen fertilisers, viz, urea and sulphate of ammonia used in this experiment. This was true for both the soils used in the pot experiment, viz, a virgin soil and a soil with a background of nitrogen residue from long-term fertiliser nitrogen application. These unexpected results could be due to the indifferent growth of plants in small pots for rather a short period of time (about a year) and, as such, it has been planned to repeat the experiment using large-sized pots and extending the growth period as much as possible.

Studies on Nitrate Nitrogen Content of Soil and "Two and A Bud" Plucked Shoot

The experimental details have been given in Ann. Sci. Rept., 1981-82, p. 26.

The relationships observed so far between yield (expressed as green leaf, kg/plot), soil NO_3-N (0-30cm) and NO_3-N content of two and a bud shoot during the cropping period May to August in long-term experiments B. 8/1 and B. 111/2 are shown in Figs. 1 and 2 respectively.

It is seen from these figures that the decline in yield in both experiments is linked with higher quantities of NO_3-N accumulation in both plucked shoots and

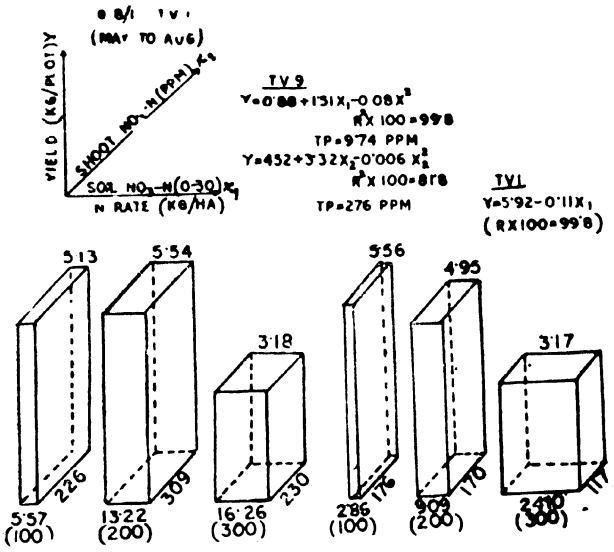


Fig 4.01. Relationships between the yield and soil NO_3-N, shoot NO_3-N

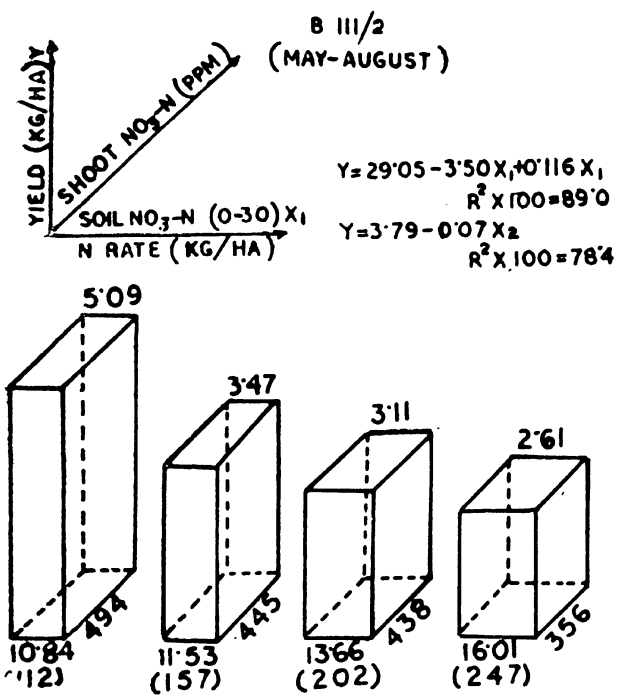


Fig 4.02. Relationships between the yield and soil NO_3-N, shoot NO_3-N

top 30 cm soil layer in the long-term experiments. It seems that under higher quantities of fertiliser nitrogen application than the optimum, lower concentration of unassimilated NO_3-N remained in plucked shoots which may be responsible for decline in yield. Figures also show that TV-9 had a higher tolerance for accumulated NO_3-N in soil (from high N manuring) than TV-1. Further continuous application of nitrogen above 100 kg/ha not only affected yield adversely but also the feeder roots were seriously damaged as shown in Plate 1.

Plate 1. Root morphology of high nitrogen plot as compared to normal fertilization

It seems that accumulation of higher quantities of nitrate nitrogen in soil solution since the begining of this long-term trial has resulted in decay of feeder roots.

Comparison between yield, NO_3-N content of top 30 cm soil layer and NO_3-N content of plucked shoots was also made for the cropping period September to November (i.e. the back-end crop) and the data are presented in table 4.01.

Development of Rapid NO_3-N Test in Soil

A rapid and accurate method known as "Orange I method", reported from Nigeria, was tried out with an aim to replace the phenol-disulphonic acid method commonly used which is time consuming and not very suited as a rapid soil test method.

Fifty six soils from the various regions of North East India were analysed for NO_3-N by both methods and the relationship between two methods is shown in Fig. 4.03.

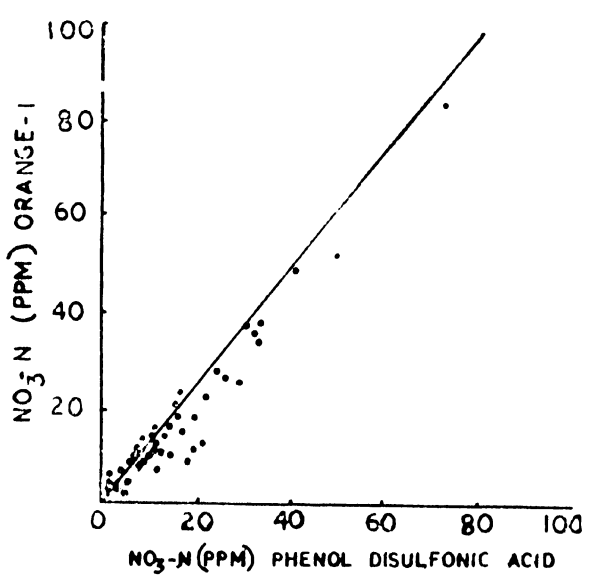


Fig 4.03. Relationship between the two methods of soil NO_3-N estimation

Table 4.01. *Relationships between yield (Green leaf in kg/plot) soil NO_3-N (0-30cm) and plucked shoot NO_3-N in B8/1 and B111/2 experiments (September to November '81)*

Clone	N (Kg/ha)	Mean yield (Y) (Kg/plot)	Mean soil NO_3-N (X_1) (ppm)	Mean plucked NO_3-N (X_2) (ppm)	Regression	$R^2 \times 100$ (%)
				B 8/1		
TV9	100	5.81	1.07	77	$Y = 11.43 - 6.45X_1 + 1.12X_1^2$	99.9
	200	4.77	4.41	76	$Y = -423.015 + 10.16X_2 - 0.0596X_2^2$	99.9
	300	2.93	3.70	96		
TV1	100	5.71	0.88	103	$Y = 5.92 - 0.11X_1$	99.8
	200	5.03	1.63	76	$Y = -452.54 - 10.25X_2 + 0.0574X_2^2$	99.9
	300	2.21	6.28	78		
				B111/2		
TV8	112	5.24	2.57	262	$Y = 13.62 - 4.59X_1 + 0.50X_1^2$	80.7
	157	3.68	4.54	328	$Y = 70.33 - 0.43X_2 + 0.0007X_2^2$	56.1
	202	3.41	5.52	348		
	247	2.87	3.87	293		

The relationship was found to be linear and highly significant ($P \leq 0.001$), expressed by the equation : $Y = 0.034 + 1.054 \times$ ($r^2 = 0.93$), where X represents NO_3-N content of soil determined by phenol disulphonic acid method and y represents NO_3-N content of soil determined by Orange I method. Thus Orange I method can be advantageously used for rapid analysis of soil NO_3-N content in future.

Field Trial Using N-Serve

The effect of the nitrification inhibitor mixed with urea on yield of tea was started in a field trial in 1979, where N was applied at rates 0, 100, 200 and 300 kg N/ha and N-serve at 0, 1 and 3% levels. The effect of nitrogen levels on the total nitrogen content of top soil and plucked shoots was followed throughout the cropping season at bimonthly intervals since the begining of the experiment. Results so far obtained (1979-1982) show that:

(i) N-serve did not significantly effect total nitrogen content of top soil and plucked shoot as well as yield of tea.

(ii) Total nitrogen content of plucked shoot irrespective of the season increased progressively with increasing rates of application of nitrogen, although the difference between nitrogen application rates 200 and 300 kg/ha was not statistically significant.

(iii) Total nitrogen content of top soil irrespective of the season also increased progressively with increasing rates of nitrogen application upto 200 kg/ha. The extent of increase of soil nitrogen with increasing N levels was of lesser magnitude compared to the shoot nitrogen as mentioned under (ii) above.

(iv) Total nitrogen contents of top soil and plucked shoot in this experiment were found to be significantly ($P \leq 0.001$) correlated with the annual yield of tea since 1979 as shown in Fig. 4.04.

Combined analysis of four years data show that yield of tea can be reliably predicted from either total nitrogen content of plucked shoot ($r^2 = 0.79$) or total nitrogen content of top soil ($r^2 = 0.74$).

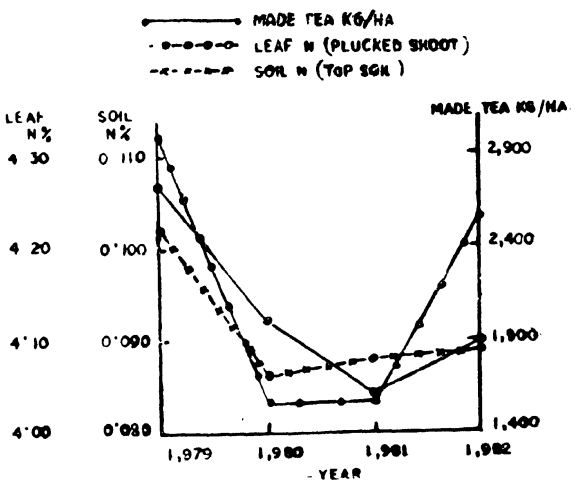


Fig 4.04. Yearly variation of leaf nitrogen, soil nitrogen and yield of tea irrespective of nitrogen treatments

Nitrate Reductase Activity

This project (1980-83) has been completed and a scientific paper incorporating all the results have been sent out for publication in outside journal. In essence the project relates to determining nitrate reductase activity or nitrogen use efficiency by young tea at different growth periods under the influence of different forms and levels of nitrogenous fertilisers (potassium nitrate and sulphate of ammonia), with and without shade. The main conclusions drawn from this experiment are:

(i) The seasonal variations of nitrate reductase activity showed that the enzyme activity reached the peak value after one month from the time of fertiliser application and, thereafter, its activity was found to decline with fluctuations.

(ii) Nitrate reductase activity significantly ($P \leq 0.001$) decreased above the level of 100 kg N per hectare in case of potassium nitrate and 150 kg N per hectare in case of sulphate of ammonia respectively.

(iii) Nitrate reductase activity was consistently higher under shade (50% sunlight) than under full sun treatment.

(iv) A positive linear correlation ($r = 0.74^{**}$, $n > 20$) was observed between uptake of total reduced nitrogen

by young tea and nitrate reductase activity of tea leaf during the same growth period.

(v) Clones differed in their levels of nitrate reductase activity. It was observed that clone TV7, which is of "Chinary" type had the lowest nitrate reductase activity. TV1, TV16 and TV20 had the highest nitrate reductase activity compared to all other clones included in this study. TV11, TV13 and TV18 occupied the intermediate position as far as the nitrate reductase activity was concerned.

These findings suggest that nitrogen fertiliser as ammonia form is more beneficial to tea plant under North East India acid soil conditions as compared to the nitrate form and shade has more pronounced effect on dry matter, reduced nitrogen and nitrate reductase activity in young tea. It also appears that those clones which are photosynthetically more efficient would enhance nitrogen assimilation. Further it is also observed that the nitrate reductase assay can be used as an important parameter for finding out the nitrogen fertiliser requirement of tea grown under different soil and climatic conditions and thus nitrate reductase test may contribute to the optimisation of nitrogen fertiliser usage.

Studies on coated and Slow Release Nitrogenous Fertilisers

Estimation of nitrogen losses in the leachates due to single and split application of slow acting nitrogen fertilisers in the forms of neem cake + urea, cattle manure + urea and urea alone in glasshouse pot experiment has been completed. Analysis of total nitrogen content in soils as well as in the harvested plant samples (i.e. leaf, stem and roots) are in progress for computation of balance sheet and finding out applied nitrogen recovery by the harvested plants at the end of the experiment.

However, it is interesting to find that splitting irrespective of the form of nitrogenous fertiliser resulted in significant reduction of leaching loss of nitrogen as shown in Table 4.02.

Table 4.02. *Leaching loss of nitrogen as influenced by form and method of application of nitrogenous fertilisers (data as p.c. nitrogen lost per pot).*

Treatment	MgN applied/ pot	Urea		Urea+Neemcake at 1:3 ratio		Urea+Neemcake at 1:5 ratio	
		Single Appln.	Split Appln.	Single Appln.	Split Appln.	Single Appln.	Split Appln.
Control	—	—					
100kg N/ha	364	44	30	35	28	35	30
200 " "	728	50	39	43	31	42	38
300 " "	1092	46	40	45	28	40	30

Further it is observed that although neemcake coated urea reduced leaching loss of nitrogen by 6 to 9% (depending upon N levels) as compared to urea alone applied in one dose, yet further substantial reduction in N leaching loss was effected by split application of neemcake coated urea as compared to single application (see table 4.03).

It was also observed that mixing urea with cattle manure at 1:1 ratio, specially at higher level of N application, e.g., 300 kg/ha, resulted in reducing leaching loss of nitrogen to the extent of 16%. Further work is in progress in this direction.

Residual Effects of Long-term Phosphate Manuring

The long-term trial B. 105 at Borbhetta Field Station, started by the Agronomy Department in 1960, was monitored all throughout the year at monthly interval from May to November in 1982 to follow up the changes in soil and shoot (two and a bud) phosphate status and correlating with monthly yield. For experimental details, please see Ann. Sci. Rept., 1981-82, p. 29.

The results are shown in Fig. 4.05.

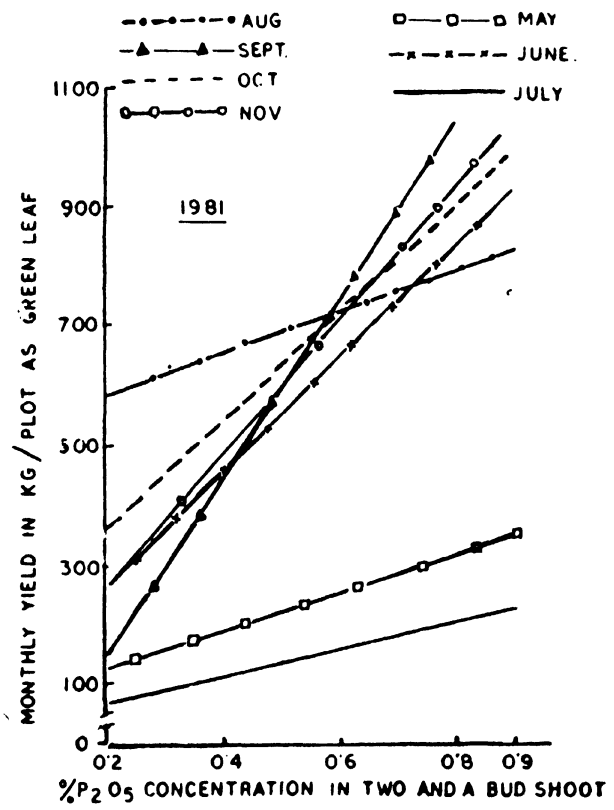


Fig 4.05.. Relationship between monthly yield in long-term experiment and phosphate concentration of two and a bud plucked shoot.

It was observed that shoot phosphate concentrations in the months of June, July were significantly correlated with monthly yield ($P \leq 0.01$, $r = 0.397$ in June and 0.373 in July), whereas the relationships between shoot phosphate concentration and yield were not significant for the months of May, August, October and November. During September although the relationship was found to be significant ($P \leq 0.05$, $r = 0.33$), it did not reach the same level of significance

as those observed in June and July months. The regression equations for the months of June and July were respectively:

$Y = 184.32 + 899.29 \times$ and $Y = 76.44 + 948.03x$, where Y = monthly yield in kg/plot and x = p.c. P_2O_5 concentration in two and a bud shoot. It is also interesting to observe that monthly yield irrespective of months maintained a linear relationship with shoot phosphate concentration, although this relationship was not always found to be significant.

The relationship between shoot phosphate concentration and the total annual yield was found to be highly significant ($P \leq 0.001$), with a predictibility of 92% ($y^2 = 0.92$) as shown in Fig. 4.06.

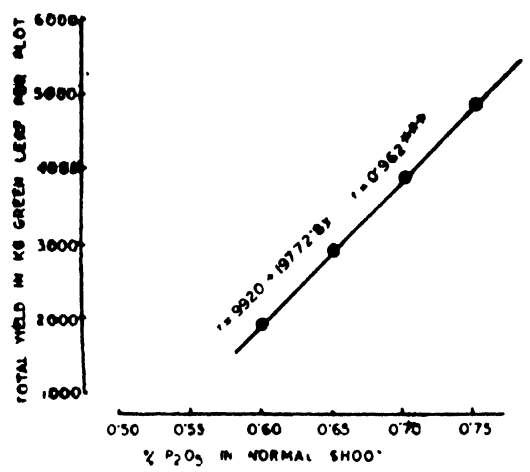


Fig 4.06. Relationship between annual yield in long-term experiment and phosphate concentration of two and a bud plucked shoot.

It is seen that within the concentration range of shoot phosphate between 0.55 and 0.80 p.c., a linear increase took place in yield.

It was also interesting to observe that the available soil phosphate (Bray I fraction) of the previous month (for example May) in top 15 cm layer was significantly ($P \leq 0.01$) correlated with the shoot phosphate concentration of the following month (in this case June). This was mostly true for the main cropping months June to September period.

The relationship between soil available phosphate (Bray I fraction) and the total annual yield (Fig. 4.07) was also found to be significant ($P \leq 0.05$) with a predictibility of 66% ($r^2 = 0.6068$).

It is seen that with the increasing available phosphate content in top 15 cm layer between 50 and 350 ppm, the yield increased progressively in a linear way. However, the predictibility was of higher order between shoot P_2O_5 concentration and yield than in the case of soil available (Bray I) P_2O_5 content and yield.

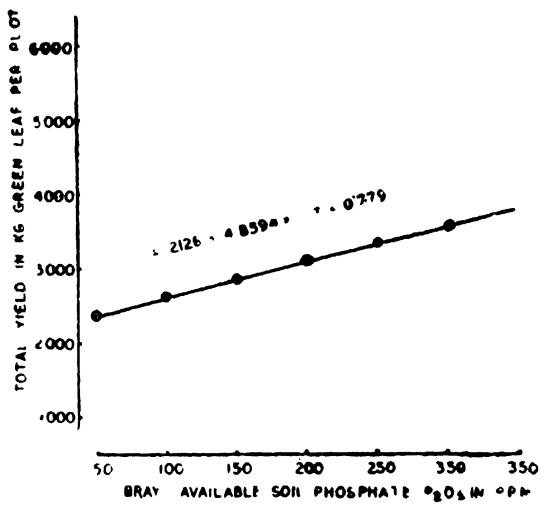


Fig 4.07. Relationship between annual yield in long-term experiment and available phosphate content of top 15 cm soil.

Effects of Phosphate, Mulch and Chemical weed control on feeder Roots and Uptake of Phosphate

For experimental details, please see Ann. Sci. Rept., 1981-82, p. 18.

(a) Feeder roots

The influence of phosphate application on the production of feeder roots was ascertained during the wet period of 1982 (July to September months) by taking undisturbed core samples on a monthly basis. Results are given in Table 4.03.

Table 4.03. *Influence of long-term phosphate fertilisation on production of feeder roots.*

Levels of phosphate fertiliser applied	Kg/ha feeder root in top 8cm soil layer
Control (no phosphate applied)	304
100 kg P_2O_5/ha	497
200%„ „	480

C.D. at 0.1% = 254, C.D. at 1.0% = 189, C.D. at 5.0% = 139.

It is seen that with 100 kg/ha P_2O_5 application for a long-time, feeder root production increased significantly ($P \leq 0.05$) in top 20 cm. soil layer, but with further increase in the phosphate dose feeder root production virtually remained unaltered. The effect of mulch on feeder root production was, however, found to be much more pronounced ($P \leq 0.001$) as shown in Fig. 4.08.

It is seen that mulch increased production of feeder roots in top 20 cm soil layers by about 65%, thereby suggesting possibility of interception of applied nutrients in much more effective way than in unmulched soil.

(b) Soil available phosphate status

The influence of long-term phosphate manuring on the available phosphate content (Bray I fraction) of top 15 cm soil layer is shown in Fig. 4.09.

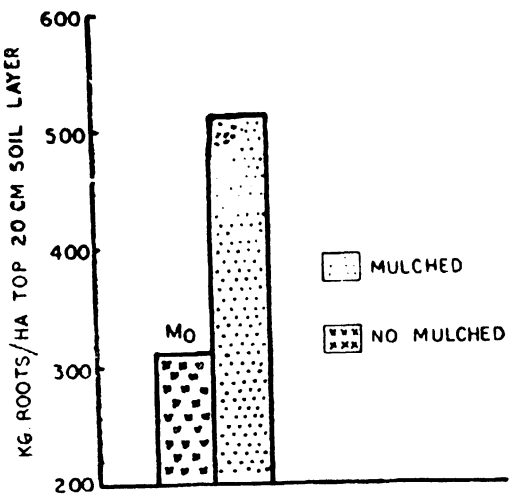


Fig 4.08. Effect of mulch on feeder roots production

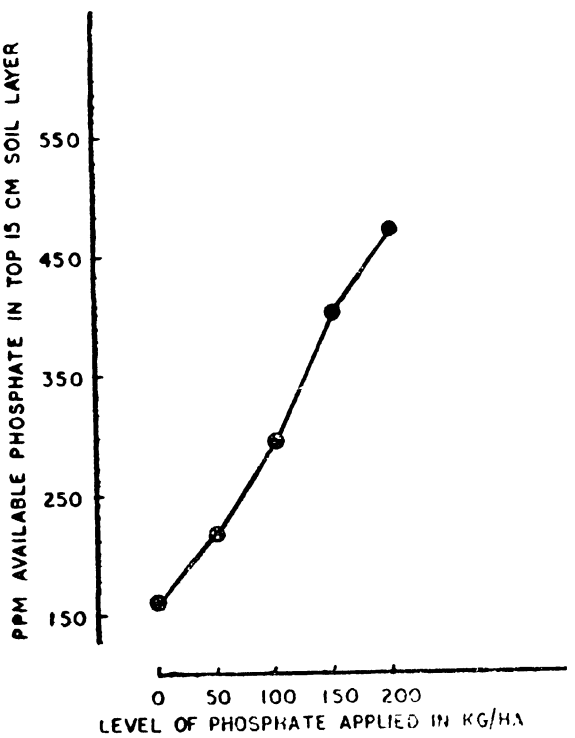


Fig 4.09. The influence of long-term phosphate manuring on the available phosphate (Bray I fraction) content of top 15cm soil

It is seen that the available phosphate fraction increased progressively in a very significant way ($P \leqslant 0.001$) with the increasing levels of phosphate application for a long time. In fact available phosphate almost doubled with 100 kg P_2O_5/ha and trebled with 200 kg P_2O_5/ha application rates respectively for a period of over 15 years or so.

(c) Phosphate uptake and yield: (Area B. 23/3)

However neither phosphate uptake nor yield were significantly affected by the levels of phosphate manuring for a long period, contrary to the other long-term phosphate manuring experiment (B. 105) described earlier, where both leaf phosphate concentration and yield increased significantly with increasing levels of phosphate application upto 90 kg P_2O_5/ha application rate. The lack of response to applied phosphate in this experiment can be due to the fact that tissue phosphate concentration of the plants of control (no phosphate) plot was of a very high order (0.965%) attaining a level more than the 180 kg P_2O_5/ha plot of B.105 long-term experiment. Such unusual P_2O_5 concentration of leaf (Two and a bud or third leaf) may owe it's origin to the past residues of phosphate fertilisation (before this experiment was started) in this field trial (B. 23/3).

Studies on Phosphate Availability From Various Sources

In this pot experiment carried out under glasshouse conditions three forms of phosphate, viz, single superphosphate, rock phosphate and ½ single super and ½ rock phosphate, each were applied at rates 0, 180, 360 and 540 kg P_2O_5/ha in two split doses to eighteen months old young tea for a period of one year at the end of which plants were harvested.

Soil available phosphate (Bray I fraction) was analysed at bimonthly intervals and the data were statistically analysed. The combined analysis has shown that irrespective of the season of sampling and levels of phosphate applied, phosphorus source significantly ($P \leqslant 0.001$) affected Bray I available phosphate content of soil (Table 4.04).

Table 4.04. *Influence of various phosphate sources on Bray I available phosphate fraction of soil.*

Forms of phosphate applied	Bray I available phosphate content of soil (p.p.m. P_2O_5)
F_1: Single Superphosphate	181.203
F_2: Rock phosphate	118.502
F_3: Half single super + half rock phosphate	151.844
C.D. at 0.1% = 27.978***	

Further Bray I available phosphate fraction virtually remained unaltered with increasing levels of application upto 540 kg P_2O_5/ha in the form of rock phosphate within a short period of one year (Table 4.05.)

Table 4.05. *Influence of different levels and forms of applied phosphate on the Bray I available soil phosphate over a period of one year (data as p.p.m. P_2O_5)*

Levels of phosphate \ Forms of phosphate	Single Super phospahte	Rock phosphate	½ single super + ½ rock phosphate
0 kg P_2O_5/ha	128.75	128.75	128.75
180 " "	166.56	119.50	148.50
360 " "	194.44	121.00	159.13
540 " "	235.06	125.00	171.00
C.D. at 0.1% = 55.96, at 1.0% = 42.20, at 5% = 31.34			

However Bray I available soil phosphate increased progressively in a significant way with increasing levels of application of phosphate in the form of single superphosphate and ½ Super + ½ Rock phosphate treatments. It appears that priming of rock phosphate with soluble phosphate fertiliser like single super phosphate is necessary for ensuring adequate release of applied phosphate in the available pool over a short period of one year. It was also observed that 180 and 360 kg P_2O_5/ha in superphosphate form were almost as effective as 360 and 540 kg P_2O_5/ha in the form of ½ rock + ½ Super for maintaining the same levels of available soil phosphate.

However Bray II available soil phosphate (potentially available) showed that half super + ½ rock phosphate treatment was as good as single super for long-term availability of applied phosphorus (Table 4.06). Bray II available phosphate also increased slightly in a progressive way with increasing levels of applied phosphate as rock phosphate although not significant statistically.

Table 4.06. *Influence of different levels and forms of applied phosphate on the Bray II available soil phosphate over a period of one year (data as ppm P_2O_5)*

P Levels	Forms of P	Single Superphosphate	Rock Phosphate	½P + ½rock
0 kg P_2O_5/ha		288.12	288.12	288.12
180 " "		338.19	310.50	347.62
360 " "		367.63	316.12	365.25
540 " "		444.25	333.50	379.56

C.D. at 0.1% = 87.00, C.D. at 1% = 65.62, C.D. at 5% = 48.7

Interestingly it was also observed that both Bray I and Bray II available soil phosphate fractions reached peak values one month after application of P fertilisers irrespective of levels and forms and thereafter steadily declined during the main cropping period (from June to October) ultimately stabilising in December. This seasonal trend of soil available phosphate fractions suggest that uptake of phosphorus by young plant was at its maximum during the period of high rate of growth.

Influence of Depth of Placement and P Forms on Soil Available Phosphate and P uptake

For experimental details please see Ann. Sci. Rept., 1980-81, p. 23. The changes in available soil phosphate fractions due to various treatments were followed up for two years since 1981 and the overall conclusions are given below:

(i) Both single superphosphate and half rock plus half superphosphate treatments irrespective of the levels of application resulted in significantly ($P \leqslant 0.05$) higher quantity of available soil phosphate as compared to the rock phosphate treatment alone.

(ii) The available soil phosphate increased significantly ($P \leqslant 0.05$) with increasing levels of application of phosphate for a period of three years and this was true for all the different forms of phosphorus used in this trial, viz, single superphosphate, rock phosphate and ½ super + ½ rock phosphate.

(iii) Placement at 5 cm depth resulted in significantly ($P \leqslant 0.001$) highest amount of available soil phosphate (Bray I) compared to 10 and 20 cm depths and there had been no significant difference in phosphate available between depths of placement 10 and 20 cm.

(iv) Available soil phosphate (Bray I fraction) declined progressively in a very significant way ($P \leqslant 0.001$) during the cropping season May to December reaching an equilibrium value during the dry period December to March. The decline in soil available phosphate during the eight month period was observed to be about 32 percent from the peak value attained in May after manuring.

(v) Uptake of phosphate by young tea also increased significantly ($P \leqslant 0.05$) with increasing levels of application of phosphate in either soluble single superphosphate or half super plus half rock phosphate forms.

(vi) Bray I soil available phosphate determined at the end of the experiment (after three years) after harvesting the potted plants on correlating with phosphate uptake by young tea showed a linear relationship (Fig. 4.10) expresssed by the regression equation:

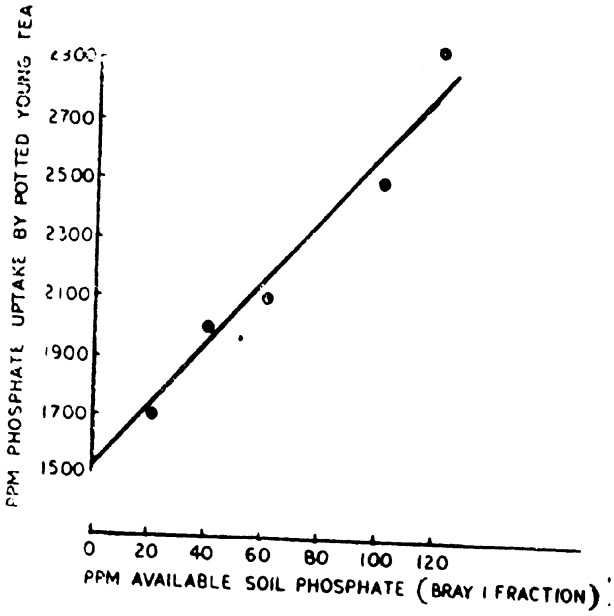


Fig 4.10. Correlation between soil available phosphate and phosphate uptake by young tea grown in pots for three years

$Y = 1519.7 + 11.0412X$, ($r = 0.3265$, $P \leqslant 0.05$), where

Y = uptake of phosphorus by plant in p.p.m. and X = Bray I soil available phosphate fraction.

The above relationship was obtained irrespective of the depth of placement of phosphate and various phosphate forms used in this experiment.

Residual Effects of Long-Term Potash Manuring

The changes in soil and shoot (Two and a Bud) potash status due to long-term manuring in field trial B. 105 at Borbhetta Field Station was followed up at monthly interval from May to November in 1982 with a view to correlate monthly yield with either soil available potash content or leaf potash concentration. For experimental details please see Ann. Sci. Rept., 1981-82, p. 29.

The main conclusions drawn from the correlation studies carried out are:

(i) Both p.c. potash concentration in two and a bud shoot and the exchangeable (available) potash content of top soil (0-15cm) were significantly correlated with the yield as shown in Figs. 4.11 and 4.12 respectively.

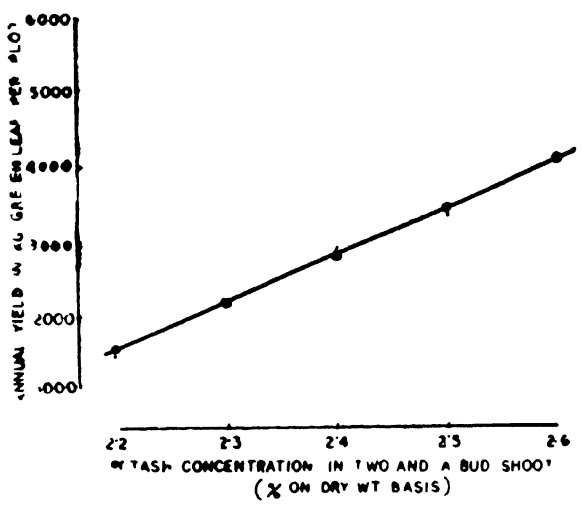


Fig 4.11. Correlation between potash concentration of two and a bud shoot and yield in long-term manuring trial at Borbhetta Field Station.

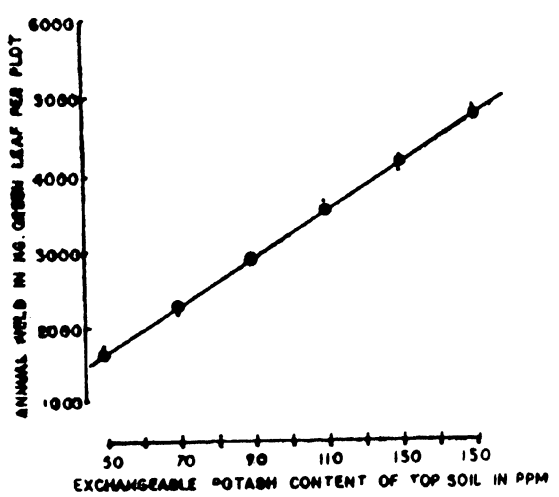


Fig 4.12. Correlation between exchangeable potash content of top soil and yield in long-term manuring trial at Borbhetta Field Station.

(a) $Y = 11793.7 + 6078.11x$ ($r^2 = 0.82$), where y = yield in kg green leaf per plot and x = p.c. potash concentration in two and a bud shoot.

(b) $Y = 143.311 + 30.8839 \times$ ($r^2 = 0.87$), where Y = yield in kg green leaf per plot and x = p.p.m. exchangeable (available) potash content of top soil (0-15cm).

(ii) Potassium concentration of both third leaf and two and a bud shoot increased linearly in a significant ($P \leq 0.001$) way with increasing levels of potash application upto 180 kg K_2O/ha for a long time. However potash concentration of third leaf at each level of K_2O application was found to be higher than in two and a bud shoot sample.

(iii) From the seasonal trend of leaf potash concentration it was observed that two distinct peaks in leaf K_2O concentration in June and September months respectively were followed by distinct decline in each case for a period of two months.

(iv) Exchangeable (available) potash content of soil reached peak value in May within one month from the time of application of fertiliser and thereafter declined steadily in a significant ($P \leq 0.001$) way until the end of cropping season.

(v) Exchangeable potash content of soil increased linearly in a significant ($P \leq 0.001$) way with increasing levels of application of potash for a long time. However the residual effect of long-term potash manuring was found to be very much pronounced in the top soil layer (0-15 cm) than in successive 15 cm sub-soil layers. Due to long-term fertilisation top 45 cm soil profile was very much enriched in potash and further down the profile upto 90 cm the residual build up of available potash was not appreciable.

Trace Elements

(a) **Foliar vs Soil application of boron in nursery plants**

An experiment was carried out using clonal sleeve plants and applying boron as boric acid at rates 1 and 2 kg B/ha by two methods, viz, foliar and soil application to find out the efficiency of method of application as far as short-term uptake is concerned. Soil application was made in single operation, whereas foliar application was given in 12 sprays (fluid concentration 0.5%) at fortnightly interval. Plants were harvested at the end of two, four and six month periods and analysed for boron uptake.

It was observed that virtually there was no difference in boron uptake between 1 and 2 kg B/ha by soil application method at 2, 4 and 6 months growing period of nursery plants (10 month old). However, boron uptake increased by 50% approximately irrespective of the levels of application compared to the control treatment.

In foliar application method boron uptake increased remarkably with doubling the rate of application, for instance, boron uptake was observed to be twice as much @ 2 kg B/ha compared to 1 kg B/ha rate of application over a six month period. Uptake efficiency-wise foliar method of application resulted in 10-20% higher uptake as compared to soil application method at lower and higher doses of boron respectively. Uptake of boron did not increase at all (when B was combined with Mn at rates 10 and 20 kg Mn/ha; B 1 kg/ha and Mn 10 kg/ha and B 2 kg/ha + Mn 20 kg/ha) by both soil and foliar methods of application, suggesting thereby absence of any synergestic effect between boron and manganese.

(b) Effect of boron and calcium application on boron uptake by young tea

For experimental details please see Ann. Sci. Rept., 1980-81, p. 30. Harvested plant materials at the end of two years growing period were analysed for estimating boron uptake by plants under various treatments. Table 4.07 shows that boron uptake increased progressively in a significant way ($P \leqslant 0.001$) by all the plant fractions with increasing levels of boron application upto 4 kg/ha over three years growth period of young tea.

Table 4.07. *Boron uptake by various plant fractions of young tea over a period of three years (data as ppm boron content per plant pot)*

Plant fractions	Rate of application and boron kg B/ha					C.D. at
	0	1	2	4	Mean	0.1%
Leaf	64.04	144.31	214.49	270.93	173.44	16.92
Stem	57.31	82.22	98.04	154.48	98.01	10.18
Root	17.45	27.82	28.90	43.73	29.48	3.99
Total	138.80	254.35	341.43	469.14	300.93	

Further boron uptake by plant fractions increased in the order leaf > stem > root. From the total uptake data it can be seen that boron uptake by young tea plant increased linearly with increased levels of application of boron in soil over a three year period.

The negative effect of calcium on boron uptake can be seen from table 4.08.

Table 4.08. *Boron uptake by various plant fractions of young tea as influenced by simultaneous application of calcium and boron (data as ppm boron content per plant pot).*

Plant fractions	Rate of application of calcium, kg Ca/ha					C.D. at
	0	10	20	40	Mean	5%
Leaf	181.36	178.29	167.66	166.47	173.44	11.60
Stem	109.29	100.12	87.30	95.34	98.01	6.98
Root	30.61	29.80	26.03	31.47	29.48	2.74
Total	321.26	308.21	280.99	293.28	300.93	

It is seen that boron uptake irrespective of the plant fractions progressively decreased with increasing rates of calcium application. However the negative effect was very remarkable at calcium application rates 20 and 40 kg/ha respectively. Total boron uptake by young tea appeared to have decreased linearly with increasing levels of application of calcium in soil simultaneously with boron over a three year period. As far as the plant fractions are concerned the negative effect of calcium on boron uptake was more pronounced in case of leaf and stem as compared to root. However Ca × B interaction on uptake of boron by young tea was found to be significant ($P \leqslant 0.05$) in all the plant fractions.

(c) Effect of simultaneous application of boron and calcium on boron contents (concentration) of various plant fractions of young tea

The effects of simultaneous application of boron and calcium on the boron contents of leaf, stem and root were found to be highly significant ($P \leqslant 0.001$). The depressing effect of calcium on the boron concentrations of leaf, stem and root (B × Ca interaction) was found to be much more pronounced ($P \leqslant 0.001$) as compared to the boron uptake. Data are given in tables 4.09 and 4.10.

Table 4.09. *Boron contents of various plant fractions after three years growth (data as ppm boron).*

Plant fractions	Rate of application of boron, kg B/ha					C.D. at
	0	1	2	4	Mean of levels	0.10%
Leaf	18.11	46.90	80.69	80.72	56.60	2.90
Stem	20.78	27.04	41.76	46.56	34.04	2.05
Root	5.88	9.52	12.24	14.92	10.64	0.38
Mean of plant fractions	14.92	27.82	44.90	47.40	33.76	

Table 4.10. *Boron content of various plant fractions as influenced by simultaneous application of B and Ca (data as ppm boron).*

Plant fractions	Rate of application of Calcium, kg Ca/ha					C.D. at
	0	10	20	40	Mean of levels	0.1%
Leaf	59.91	56.53	56.65	51.33	56.10	2.90
Stem	36.37	34.85	34.32	30.60	34.04	2.05
Root	11.29	10.51	10.49	10.28	10.64	0.38
Mean of plant fractions	35.86	33.96	33.82	30.74	33.60	—

From table 4.09 it is observed that boron concentration in either leaf, stem or root increased almost linearly with increasing levels of boron application. Mean boron content of plant fractions doubled and trebled with one and two kg B ha^{-1} application rates respectively. Between two and four kg ha^{-1} application rates leaf boron content however did not change appreciably. The negative effect of calcium on the boron content of various plant fractions was exhibited at its maximum at 40 kg Ca/ha application rate irrespective of the levels of boron (Table 4·10). The suppressive effect of calcium on the boron content of various plant fractions was not significant between calcium application rates 10 and 20 kg Ca/ha. As far as

the B × Ca interaction effect is concerned, the maximum suppression of boron content of plant fractions was caused by the treatment combination calcium@ 40 kg/ha and boron @ 4 kg/ha.

(d) **Correlation between available boron content of soil and uptake of boron by young tea**

At the end of the pot experiment (after 3 years), soils from pots under various treatments were analysed for available (hot water soluble) boron content and these data were correlated with boron uptake per plant pot. The relationship is shown in Fig. 4.13.

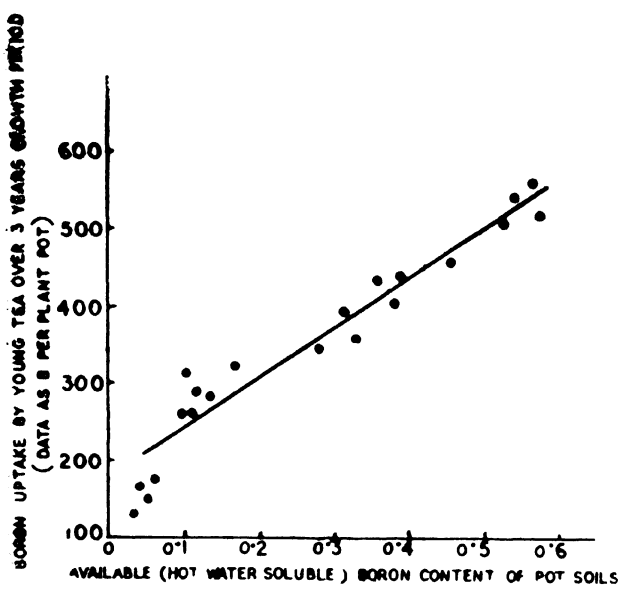


Fig 4.13. Relationship between available boron content of soil and boron uptake by young tea over three years growth period

It is seen from Fig. 4·13 that available boron content of soil was linearly correlated with boron uptake by young tea plant. The linear relationship was expressed by the regression equation:

$Y = 631.5x + 184.26$ ($P \leq 0.001$, $r^2 = 0.86$) and was found to be highly significant with a predictability of 86%. In the equation Y represents boron uptake as mg per plant pot and x represents available boron content of soil.

Effect of Vermiculite (as a soil conditioner) on Soil Physical Properties and Growth of Young Tea

(a) Laboratory Experiment

Soils belonging to three dominant soil types, viz silty clay loam (S1), sandy loam (S2) and loamy sand (S3) were each treated with vermiculite at two different ratios, viz, 70% soil and 30% vermiculite (V/V) and 50% soils and 50% vermiculite (V/V) keeping a control with no vermiculite treatment for each soil. After mixing with vermiculite each of the treated soils as well as the untreated control soil were stored in the laboratory at predetermined field capacity moisture levels for a period of three months. At the end of 3 months the treated and the control soils were dried and their soil moisture characteristics curves (pF curves) were determined as shown in Figs. 4.14a, b and c.

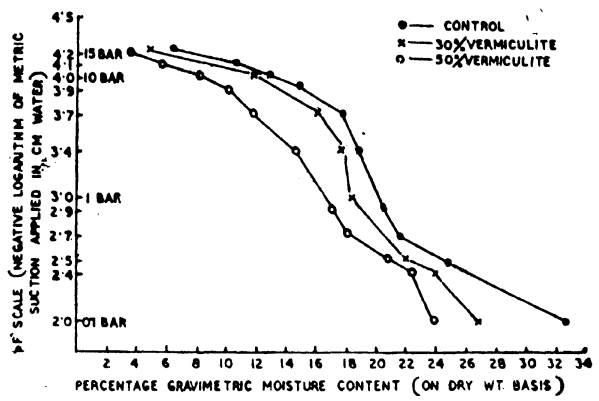


Fig 4.14(a). Soil moisture characteristic curve (pF curve) of silty clay loam soil as influenced by vermiculite treatment

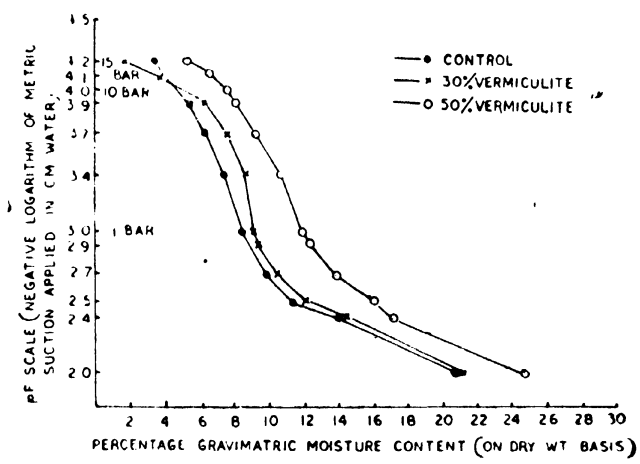


Fig 4.14(b). Soil moisture characteristic curve (pF curve) of sandy loam soil as influenced by vermiculite treatment

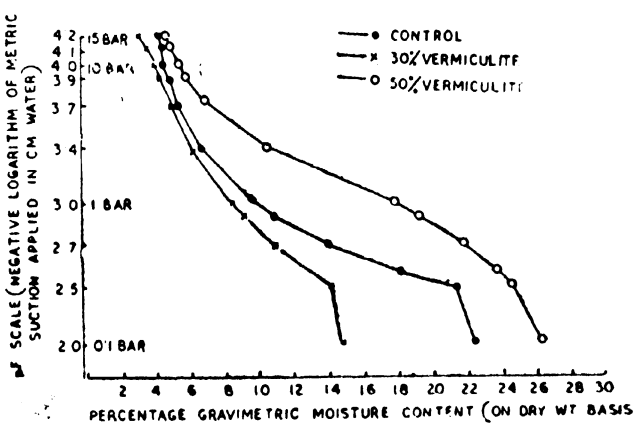


Fig 4.14(c). Soil moisture characteristic curve (pF curve) of loamy sand soil as influenced by vermiculite treatment

It is seen from Fig.4.14a that silty clay loam soil changes in moisture characteristics on treatment with vermiculite, the effect being more pronounced when soil was mixed with vermiculite at 50:50 ratio on volume basis. It appears that the pore size distribution of soil changed with vermiculite treatment and as a result percentage of macropores increased allowing enhanced release of soil water at particular metric suctions applied. However the effect of vermiculite as a soil conditioner was found to be opposite with respect to sandy loam and loamy sand soils respectively (Figs. 4.14b and 14c respectively). Moisture holding capacity of sandy soils was remarkably increased with vermiculite treatment, specially when vermiculite was mixed with soil at 50:50 ratio on volume basis. The effect of vermiculite on moisture retention capacity was found to be more pronounced with loamy sand type soil (Fig. 4.14c) than sandy loam soil (4.14b). The increased moisture holding capacity of sandy soils can be due to increased cohesion of sand particles resulting in changes in pore size distribution and increased capillary porosity.

(b) Field experiment in micro-plots

Moisture characteristic curves (pF curves) obtained with field soils after vermiculite treatment at different ratios also confirmed the results of laboratory experiment described earlier. However under field conditions soil : vermiculite ratio as 70:30 on volume basis was found to be as good or even superior to soil: vermiculite at 50:50 ratio, as far as reducing the moisture retention capacity of fine textured soil (silty clay loam/silty loam type) and increasing the moisture holding capacity of coarse textured soil sandy loam/loamy sand type) in a significant way. The observed higher efficiency of vermiculite at lower quantities under field situation could be due to increased degradation of added vermiculite for a longer period of two years during which the field experiment was carried out.

In the micro-plots (5.4 × 1.8 × 0.5 m in size) clone TV18 was planted at spacing 60 cm × 60 cm. There were 27 plants in each plot which were grown for a period of two years. There were 9 micro-plots containing three different soil types viz. silty clay loam, sandy loam and loamy sand and each soil had three treatments, viz, control (no vermiculite), soil : vermiculite :: 70:30 (V/V) and soil : vermiculite :: 50:50 (V/V). From the dry matter weight of plants recorded after harvest (Table 4.11), it was observed that theeffect of vermiculite was significant ($P \leq 0.05$) for each soil type, but interestingly the interaction between vermiculite and soil type was also found to be highly significant ($P \leq 0.001$).

The effect of vermiculite on plant gorwth was very remarkable with loamy sand type of soil, where the maximum growth was observed with 50:50 vermiculite and soil ratio by volume. Contrary to this with

Table 4.11. *Influence of vermiculite on the growth of young tea in different soil types (Mean data in gm on dry wt. basis)*

Soil / Vermiculite	Soil type: Silty clay loam	Sandy loam	Loamy sand	Mean
Control (no vermiculite)	15.02	18.22	12.24	15.16
30% vermiculite (V/V)	27.21	36.08	168.14	77.14
50% vermiculite (V/V)	19.41	27.89	547.74	198.35
Mean	20.54	27.40	242.71	

C.D. for soil type at 5% = 25.66
" " vermiculite " = 12.01
" " Soil type vermiculite 5% = 76.98

sandy loam and silty clay loam type of soil the maximum growth was observed with 30:70 vermiculite : soil ratio by volume. The root weight also proportionately increased, for example, in case of silty loam and sandy loam soils, the root weight was doubled under 30% vermiculite treatment compared to control. Increasing vermiculite to 50% did not result in any further increase in root weight. In case of loamy sand soil the root weight increased with increasing proportion of vermiculite in a very remarkable way, e.g., root weight per plant in control, 30% vermiculite and 50% vermiculite were recorded to be 4, 51 and 136 gm. respectively.

The changes in soil physical properties were followed up in the vermiculite treated field soils after harvesting the plants and the data are given in Table 4.12

Table 4.12. *Influence of vermiculite treatment on the physical properties of different soil types (mean data as percentages on dry wt. basis)*

Soil type	Vermiculite	Physical properties of soil: % water holding capacity	%total porosity	% non-capillary porosity	% capillary porosity
Silty clay loam	Control	44.95	47.09	11.33	35.76
	30% verm.	44.23	46.39	17.49	28.90
	50% verm.	44.61	45.33	15.59	30.72
Sandy loam	Control	42.00	48.32	19.22	29.09
	30% verm.	47.33	45.15	12.89	32.26
	50% "	44.02	47.49	17.49	30.00
Loamy sand	Control	40.31	45.59	17.06	28.53
	30% verm.	45.02	45.89	15.67	30.22
	50%"	45.98	46.39	15.00	31.39

It is seen from table 4.12 that water holding capacity generally changed with vermiculite treatment showing a decreasing effect in fine textured soil (silty clay loam) and an increasing effect in coarse textured soil (sandy loam/loamy sand). The total porosity virtually remained unaffected with minor exceptions, but the distribution of non-capillary and capillary pores changed remarkably specially in case of loamy sand type of soil. The effect of 30% vermiculite on physical properties was most significant irrespective of soil types, the general trend being increase of noncapillary pores and simultaneous decrease of capillary pores in case

of fine textured soil and the reverse for coarse textured soil. Besides mean wet diameter of soil aggregates was estimated on five occasions at bimonthly interval over a period of ten months, after a lapse of one year from the time vermiculite treatment was given. Results showed that mean wet diameter of soil aggregates increased remarkably in all the soil types due to vermiculite treatment. The effect was found to be highest with 30% vermiculite in silty clay loam and sandy loam type of soil, whereas with loamy sand highest effect on the mean wet diameter of aggregates was observed at 50% vermiculite treatment.

Apart from vermiculite, a number of other synthetic soil conditioners, viz, polyvinyl alcohol, malic anhydride, sodium carboxy-methyle cellulose, Agrohyde-10, Agrohyde-12 and Agrohyde-30 each at 0.05% and 0.1% were mixed with a loamy sand type of soil with a view to find out their effects on the moisture retention capacity of coarse textured soils. pF curves of the treated soils, constructed after four months of treatment in pots, showed that all the conditioners increased significantly moisture retention capacity of loamy sand soil. Agrohyde-10 gave the best results retaining 4% (W/W) more moisture than the untreated soil at applied metric suction of one atmosphere.

Determination of Design Storm for Land Drainage

Intensity-duration rainfall relationship curve was constructed using long-term rainfall data with an aim to find out design storms for the different tea growing regions. Hourly rainfall data was available from Tocklai (mid-Assam), Nagrakata (Dooars), and Silcoorie (Cachar) meteorological stations for a continuous period of 20, 10 and 12 years respectively. The analysis was carried out for the months June to August as the period coincides with highest rainfall and cropping period of the year too. The intensity-duration relationship for 100 and 10 years return periods is shown in Fig. 4.15(a), (b) and (c) for the three regions mid-Assam, Cachar and Dooars respectively. Intensity of rainfall was found to be highest irrespective of duration and return period at Central Dooars compared to the other two regions. For smaller durations, the intensity of rainfall of Cachar District was found to be fairly comparable with that of Central Assam, but with increasing duration higher intensity rainfall was observed in Cachar. In view of very high rainfall intensity, especially for shorter durations, observed in all the regions, it can be inferred that there would be considerable run-off losses in all the regions under tea. However, such loss can be maximum at Central Dooars condition. This calls for an adequate surface drainage system to facilitate disposal of run-off water. These intensity-duration curves will facilitate estimation of peak discharge rates which is very essential for purpose of designing main drains besides acquiring knowledge of soil and topography of the drainage catchment through survey.

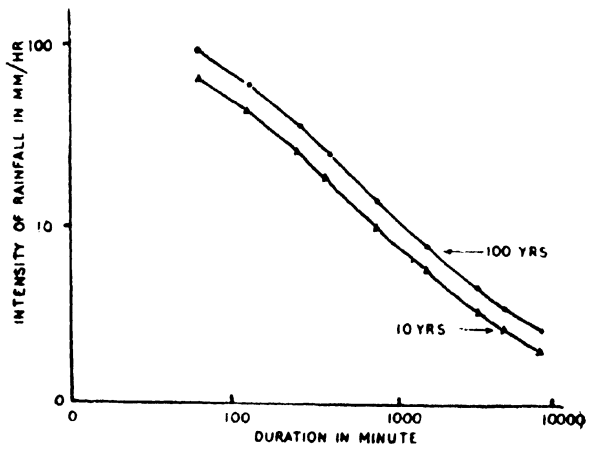


Fig 4.15 (a). Intensity-duration relationship for Central Assam

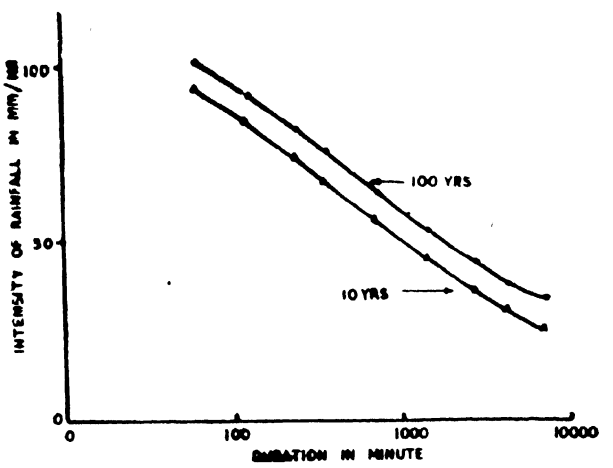


Fig 4.15(b). Intensity duration relationship for Cachar District

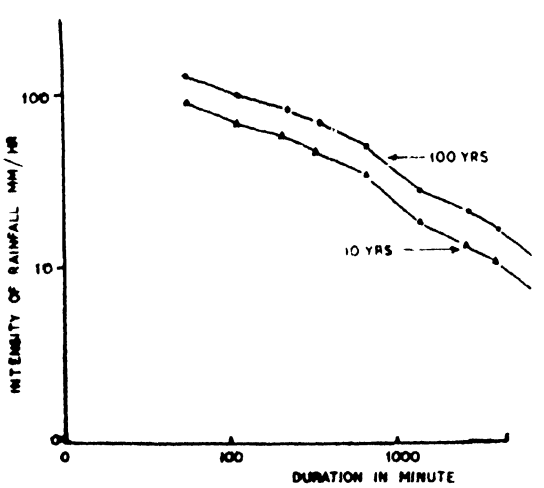


Fig 4.15(c). Intensity-duration relationship for Central Dooars

Rainfall-Run-off Relationship

Studies were undertaken to determine the rainfall-run-off relationship. From the results obtained from the experiment, located at Borbhetta field experimental station, the run-off co-efficient for areas with a very good surface drainage system was reported last year. On analysing the discharge and rainfall records for the same catchment during 1982, similar run-off co-efficients have been obtained confirming that these data can precisely be used for designing main drains of flat (< 3% slope) areas.

From the discharge hydrographs, the total volume of run-off losses were found out for different storm events with a view to find out whether any relationship existed between the volume of run-off and the rainfall received. Fig. 4.16 illustrates the relationship obtained under saturated and unsaturated soil moisture conditions of the experimental site.

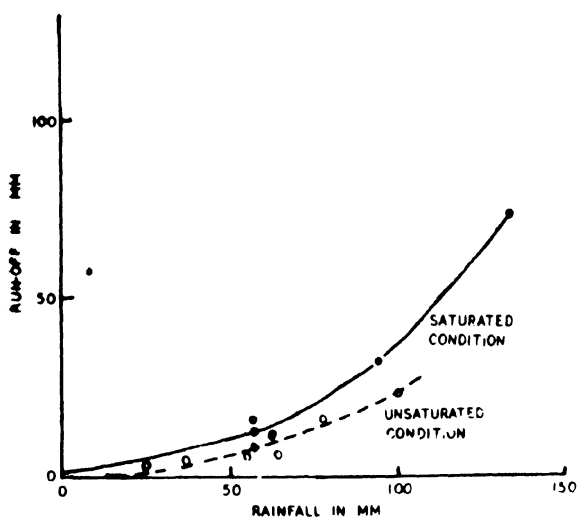


Fig 4.16. Rainfall-run-off relationship

From Fig. 4.16, run-off loss was found to be substantial even under unsaturated soil moisture condition, which was due to the high intensity of incident rainfall. Interestingly it was also found that the run-off volume from higher quantities of rainfall under saturated soil moisture condition corresponded to Curve No. 75 as obtained by the U.S. Soil Conservation Service, thereby suggesting that Curve No. 75 can be directly used for obtaining design run-off for computation of main drain size in flat areas. The saturated soil moisture condition is equivalent to (AMC) III of the U.S. Classification. Curve No. 75 will be equivalent to Curve No. 56 under U.S. Classification AMC II, i.e., unsaturated soil moisture conditions.

Effective Rainfall and Effective Porosity

Another objective of the experiment conducted at Borbhetta was to determine the effective rainfall that recharges the ground water table. The effective rainfall is the remaining quantity of total rainfall after losses takes place through run-off and evapotranspiration. Thus this part of total rainfall is only responsible for recharging water table. Run-off was found out from the discharge hydrographs recorded daily, the soil moisture deficit was calculated from the cumulative potential evapotranspirational (EPT) losses (Penman) between two storm periods.

Table 4.13. *Results on effective rainfall for different moisture deficit condition (Site : Borbhetta area 20).*

Soil moisture deficit in mm preceding rainfall	Total Rainfall in mm	Run-off loss in mm	Net effective rainfall in mm
0.0	57.0	13.8	43.2
8.2	93.8	32.4	53.2
9.4	132.7	74.9	48.4
16.7	100.8	23.3	60.8
30.1	57.0	7.9	19.0
44.5	64.1	4.1	15.5

Table 4.13 shows the amount of effective rainfall obtained under various moisture deficit conditions preceding rainfall. The maximum effective rainfall was found to be 60 mm. It is also seen that higher quantities of rainfall will cause higher run-off losses provided the moisture deficit is less, thereby decreasing the effective rainfall.

Effective porosity or air pore space was determined from effective rainfall and the actual rise of ground water table observed in this experiment (Table 4.14).

Table 4.14. *Effective porosity obtained for various soil layers under well drained condition (soil type : sandy loam) site: Borbhetta area 20.*

Soil depth in mm	Effective rainfall in mm	Water table rise in m	Effective porosity
1.05	0.0532	0.52	0.1023
1.04	0.0432	0.42	0.1029
1.06	0.0484	0.54	0.0896
1.22	0.0453	0.60	0.075
1.22	0.0312	0.38	0.0821
1.23	0.0444	0.64	0.070
1.27	0.0608	0.76	0.080
1.42	0.0084	0.24	0.035
1.47	0.0178	0.40	0.0445
1.49	0.0190	0.43	0.0442
1.90	0.0155	0.41	0.0378

From table 4.14 it is seen that variations in air pore space can occur between various soil layers of the profile. The air pore space was found to be 10% by volume within 100 cm depth, i.e., depth of collector drain in the experiment. However, the air pore space decreased to 8% and 4% by volume with the increase in depth of soil profile upto 125 and 150 cm respectively, thereby suggesting that sub-soil layer below 125 cm in this experimental site is more densly packed than the upper layers. A smaller effective porosity resulted in higher water table build up even with lower quantities of effective rainfall. However under similar situation air pore space can be increased and therefore water table can be better controlled by increasing the collector drain depth beyond 125 cm.

Water Table Fluctuation

From hourly water table measurements in the same experiment, the percentage frequency of occurrence of different water table classes for the period June to August in 1981 and 1982 is calculated and shown in Table 4.15. Although higher quantity of rainfall was recorded during the corresponding period of 1982 compared to 1981, yet the number of occasions when water table reached within 75 cm from ground surface remained virtually same in both the years. However, the number of occassions the water table was found within 125 cm layer was much more during 1982 than in 1981. Thus on an average, the rise of water table was found to be higher in 1982 than in 1981.

Table 4.15. *Frequency distribution (expressed as % of total hrs) of water table at various water table classes.*

Water table class	Percentage frequency distribution of water table	
	1981 (984.4 mm)	1982(1191.1 mm)
0-25	—	–
26-50	0.09	–
51-75	1.26	1.28
76-100	10.82	16.12
101-125	36.18	53.66
126-150	26.35	18.73
151-175	6.20	0.82
176	19.06	9.38
Total rainfall during the period mm	948.4	1191.1

The important point that emerges from these observations is that with the fairly shallow open channel intensive drainage system adopted in this field experiment ground water table could be effectively controlled at a depth of 75 cm all throughout monsoon period. This system further minimised the water table fluctuation within a depth of 100 cm from ground surface. It may be mentioned that depth of secondary and collector drains were on an average 75 and 90 cm respectively in this experiment. The secondary and collector drains were spaced at 13 m and 62 m interval respectively.

From these results it is suggested that commonly adopted spacing and depth of field and collector drains in tea areas (as in this experiment) will not be able to control ground water table below the depth of drains.

Table 4.16 shows the recession of water table after it attained very high levels. It is seen that irrespective of quantities of rainfall, water table attained 75 cm, 90 cm and 100 cm levels within 5-6 hrs, 14-15 hrs and 24 hrs respectively after the cessation of storms. However the water table recession rate beyond 100 cm was found to be 10 cm per day only, which is very sluggish. The sluggish rate of recession beyond 100 cm depth of soil profile can be explained from the effective porosity of soil layers below 100 cm and vertical deep seepage losses.

Table 4.16. *Recession of water table under well drained condition. (Site : Borbhetta Area 20)*

Events	Depth of water table in cm at following hrs.								
	0	2	4	6	12	24	48	72	96
1	45	60	70	75	87	98	—	—	—
2	57	66	74	77	89	98	109	119	127
3	56	66	74	79	86	97	109	116	126

Fig. 4.17 shows therelationship between water table depth and discharge rates obtained from this experiment. A linear relationship existed (significant at 0.1%) within the water table region of 90 cm. The water table depths were further converted into hydraulic heads (h) taking drain depth into consideration and again correlated with the discharge rates. Highly significant ($P \leq 0.001$) linear relationships were obtained between the head (h) and discharge rates (q), when the secondary and collector drains were considered seperately. From these relationships, the ratio h/q for secnodary and collector drains was found to be 2.0 and 3.5 respectively. The lower h/q values as had been observed in this experiment show that the drai nage criteria adopted for the experiment was very sharp allowing very quick recession of water table to drain bed depth. But the soil below the drain depth remained saturated for a longer duration under such sharp criteria and for controlling this aspect the drain depths need increasing beyond 75 and 90 cm for secondary and collector systems respectively.

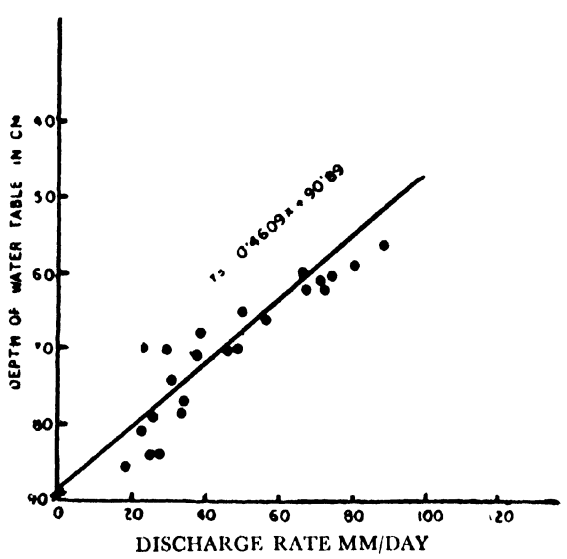


Fig 4.17. Water table discharge relationship

Pump Drainage Experiment at Haroocharai T.E.

Rainfall, water table and discharge were continuously measured during June to October in the Haroocharai T.E. pump drainage experiment for the second successive year. Intable 4.17 the totalrainfall and pump discharge (in mm) during June, July and August of 1981 and 1982 are shown.

Table 4.17. *Comparison of monthly rainfall and pump discharge quantity as observed at Haroocharai T.E. during 1981 and 1982*

Months	1981		1982	
	Rainfall in mm	Pump discharge mm	Rainfall mm	Pump discharge mm
June	331.8	36.51	446.8	—
July	401.2	109.09	315.2	37.02
August	296.6	111.94	304.4	23.68
Total	1029.6	303.74	1066.4	91.77

It is seen that the total pumping hours during 1982 was about one third of that in 1981, which was caused by frequent breakdown of pumps and electricity failure. The total rainfall however in both the years were practically of the same order.

In Table 4.18 the distribution of number of hours that the water table was found in different class intervals during this period is given. It can be seen that the total number of hours that the water table remained within 100 cm depth of soil profile was almost same in both years. But total number of hours that the water table remained within 75 cm depth was found to be more in 1982 than in 1981. Such situation was caused by lower quantities of drain discharge by pumping in 1982 than in 1981. The yield of the experimental area (50 ha) also decreased by 17 p.c. in 1982 compared to 1981, although other management factors were kept constant.

Table 4.18. *Hourly water table distribution at different water table classes during June to August in 1981 and 1982 at Haroocharai T.E.*

Water table class in m	Number of hours of occurrence of water table	
	1981	1982
0-25	47	62
26-50	118	145
51-75	357	519
76-100	1025	813
101-125	514	474
126-150	127	25
150-175	—	170

It can therefore be reasonably concluded that the main reason for the reduction in yield in 1982 is lesser pumping hours in 1982 and consequently more frequent occurrence of water table within a depth of 75 cm from ground surface during 1982. This aspect reemphasised the validity of the pump drainage criteria of 12-13 mm/day reported earlier.

Pipe Drainage Field Experiments

Behaviour of ground water table, drain discharge and weekly yield records in pipe drainage experiments located in Tocklai Division were followed up throughout the year. Some of the salient points only are mentioned below:

(a) **Ground water table behaviour**

Water table hydrographs were prepared for both 23.0 m (depth 1.5 m) and 35.5 m (depth 1.5 m) spacings (Fig. 4.18a) of PVC slotted pipe (9 cm dia.) plots.

It was observed that all throughout the cropping season 23.0 m spacing maintained a lower water table compared to 35.5 m spacing. Fig. 4.18a shows that highest rise of water table under 23.0 m spacing was within 90 cm from the ground surface, whereas for the corresponding rainfall events, highest rise of water table under 35.5 m spacing was within 60 cm from ground level. Further it can be seen from Fig. 4.18a that under 23.0 m spacing, water table generally remained below 120 cm from ground surface with minor exceptions, whereas water table remained within 100 cm from ground surface on 14 different occasions under 35.5 m spacing. Needless to emphasise that the control plots having 75 cm deep open channels and similar spacings showed much higher water table all throughout the season compared to sub-surface pipe drain plots. From these observations it can safely be concluded that with 23.0 m spacing and 1.5 m depth, fluctuations of ground water table can be effectively controlled below 90 cm from the ground surface even under peak storm period, water table mostly staying at a depth of 120 cm from ground level. This is in confirmation with the observations made earlier on the water table behaviour of deeper (pipe) drains at closer spacing.

Water table hydrographs of another field drainage experiment, where cement asbestos pipe was used at 1.5 m depth and 17.8 m spacing and compared against open channel of 0.75 m depth and 17.0 m spacing, were also prepared and shown in Fig. 4.18b. However compared to the 23.0 m spacing pipe drain plot (described above), ground water table remained much higher under 17.8 m spacing. This apparent contradiction can be explained by the fact that the discharge capacity of cement asbestos pipe of 5 cm dia. used in this experiment compared to PVC slotted pipe of 9 cm dia. was much less. Under 17.8 m spacing cement-asbestos pipe drain plot, the ground water table remained within 100 cm on thirteen different occasions. Thus the water table behaviour (Fig. 18b) under 17.8 m spacing in cement-asbestos pipe drain plot (1.5 m depth and pipe diameter 5 cm) was found to be comparable with the water table hydrograph (Fig. 4.18a) of 35.3 m spacing PVC slotted pipe drain plot (1.5 m depth and pipe diameter 9 cm), thereby suggesting that for similar water table control, doubling the discharge capacity of pipe offered the scope to widen the spacing of field drains by two times and consequently to save land considerably. Under 17.8 m spacing shallower open channel system of this experiment, water table rose within 100 cm on thirty one occasions.

Table 4.19 gives the frequency of occurrence of various water table classes during 1982 as influenced by different spacings of sub-surface pipe drains as well as pipe diameter compared to shallower open channel system.

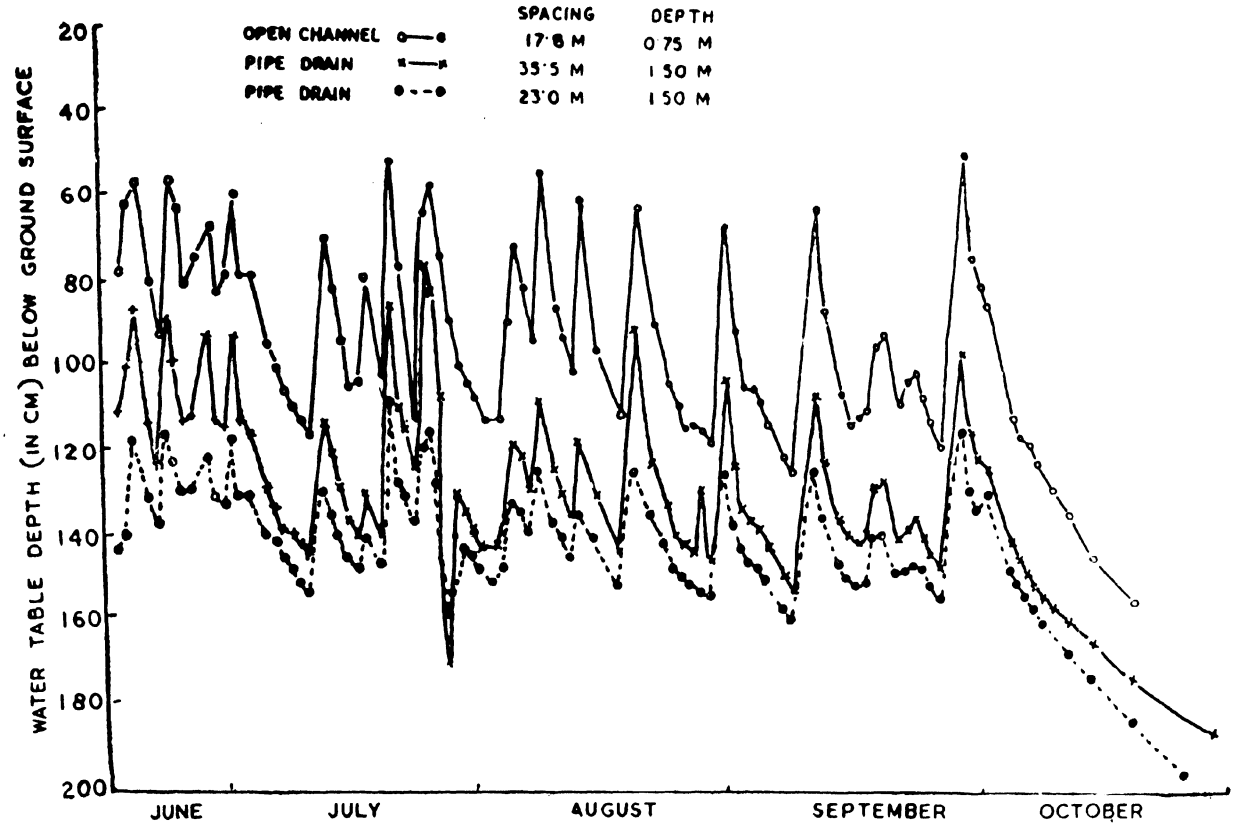


Fig 4.18(a). Water table hydrograph of different spacing of pipe drain and open channel

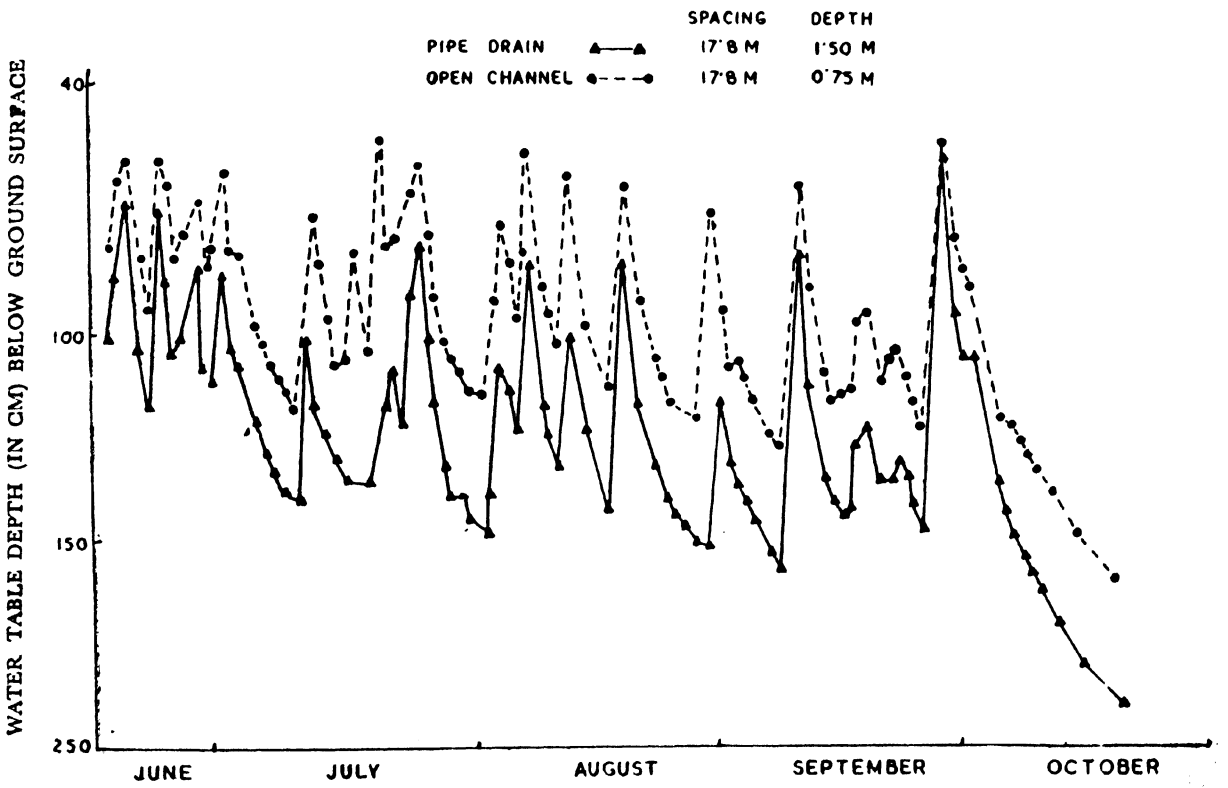


Fig 4.18 (b). Water table hydrograph of open channel and pipe drain

Table 4.19. *Number of occasions water table rose to different water table classes under various spacings of sub-surface pipe drains compared to control, i.e., shallower open channel system.*

Drain spacing / Water table class	23m spacing PVC slotted pipe 9cm dia.	35.5m spacing PVC slotted pipe 9cm dia.	17.8m spacing cement asbestos pipe, 5cm dia.	17.8m spacing 75cm deep open channel
0 - 25 m	nil	nil	nil	nil
26 - 50 m	nil	nil	nil	nil
51 - 75 m	nil	4	3	7
76 - 100 m	3	14	13	31
101 - 125 m	10	29	30	33
126 - 150 m	33	46	40	46

From the table it is observed that the number of occasions water table remained within 75 cm from ground surface are few only under pipe drains irrespective of spacing and pipe diameter compared to shallower open channel system. The same was true for frequency of occurrence within 100 cm depth. However only on 3 occasions water table rose within 100 cm under 23.0 m (PVC, 9 cm dia.) spacing and on thirteen to fourteen occasions under 35.5 m. (P V C 9cm dia.) and 17.0 m (cement asbestos 5 cm dia.) spacings. The reason for identical behaviour of latter two spacings in water table control has been mentioned earlier. However the interesting point to note that irrespective of the spacings, pipe diameter, pipe material and open or burried system, no. of occurrence of water table in deepest class, i.e., 120-150 cm from ground surface, remained almost of the same order.

(b) Head-discharge relationship

Head-discharge relationships were worked out from measured hydraulic head and discharge rate data for both the experiments described above. Significant ($P \leq 0.01$) linear relationships were observed between hydraulic head and discharge rates. These relationships offered a sound basis for designing pipe drains for different soils varying in hydraulic conductivity.

(c) Yield

As far as 1982 yield is concerned, the plot under cement asbestos pipe (5 cm dia.) at 17.0 m spacing and 1.5 m depth gave 16% more yield than the plot having 0.75 m deep, 17.0 m spacing open channel system, whereas plot under PVC slotted pipe (9 cm dia.) at 23.0 m spacing and 1.5 m depth gave about 43% more crop than the plot having same drainage material burried at same depth (1.5 m) but at 35.5 m spacing. Yield was observed to be highest in the plot having PVC slotted pipe, 9 cm dia. at 23.0 m spacing, where ground water table was also controlled generally at a depth 120 cm below ground surface. However the economic depth and spacing in relation to tea crop's sensitivity of water table fluctuations need further investigation.

Calibration of Neucleonic Moisture-Density Gauge

The relationships between p.c. moisture (V/V) and the count ratio in a soil having a bulk density of 1.4 g/cc is shown in Fig. 4.19.

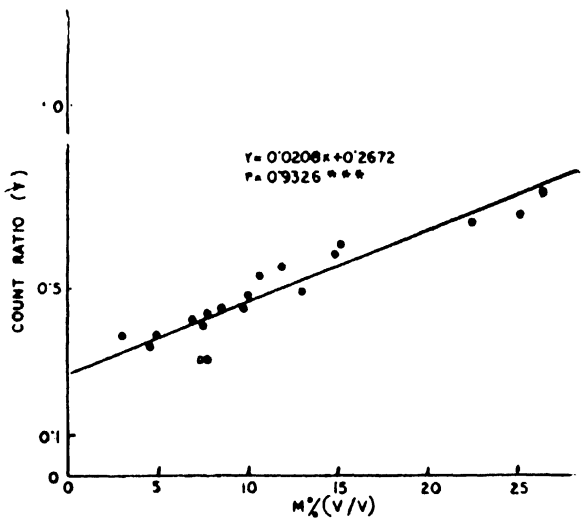


Fig 4.19. Relationship between M% (V/V) and count ratio for Tocklai soil of bulk density 1.40 g/cc

The linear relationship is expressed by the equation- $Y = 0.0208x + 0.2672$ (and found to be highly significant ($P \leq 0.001$) with a r^2 value = 0.87, where Y= count ratio and x = % moisture (V/V). Work is in progress to find out similar relationships for different soils varying in bulk densities and once these relationships are established, volumetric moisture content of soil profiles under different intensities of drainage can be estimated *in situ* rapidly and accurately by use of nucleonic method.

Climatological Studies

(a) Rainfall analysis

Rainfall and rainy days according to the categories of daily rain for winter, pre-monsoon, monsoon and post-monsoon seasons were analysed using data from 1921 to 1980 recorded at Tocklai Experimental Station as shown in Table 4.20.

It is seen that in winter period 97% of daily rain belonged to category 0.01 to 3.0 cm per day, in pre-monsoon period 60% of daily rain belonged to category 0.01 to 3.0 cm per day and the remaining 40% belonged to category 3.1 to 10.0 cm per day. In monsoon periods both categories seemed to be almost equally distributed. However 23% of the daily rain in monsoon belonged to high intensity group with a rainfall quantity of 5 to 10.0 cm per day. Distribution in post-monsoon period followed the same trend as that of premonsoon period, i.e., 66% in the category 0.01 to 3.0 cm per day and remaining 34% in the category 3.1 to 10.0 cm per day.

Table 4.20. *Rainfall according to category of daily rain (1921-1980) as % of total rainfall.*

	0.01 to 0.2 cm/ day	0.3 to 1.0 cm/ day	1.1 to 2.0 cm/ day	2.1 to 3.0 cm/ day	3.1 to 4.0 cm/ day	4.1 to 5.0 cm/ day	5.1 to 10.0 cm/ day	10.0 cm/ day	Total
Winter	11	47	30	9	3	--	---	—	100
Pre-monsoon	2	16	23	19	13	11	14	2	100
Monsoon	2	12	18	16	14	11	23	4	100
Post-monsoon	4	19	21	22	15	8	10	1	100
	Raindays according to category of daily rain (1921-80) expressed as % of total number of rain days.								
Winter	49	39	10	2	0	—	—	—	100
Pre-monsoon	30	33	19	9	4	3	2	0	100
Monsoon	27	30	18	10	6	3	5	1	100
Post-monsoon	39	32	13	8	4	2	2	0	100

Another interesting feature was that 40, 52 and 34 percent of high intensity rain (category 3.1 to 10.0 cm per day) in pre-monsoon, monsoon and post-monsoon periods respectively were governed by merely 9, 15 and 8% of rainy days during pre-monsoon, monsoon and post-monsoon seasons respectively. Thus 85 to 100% of rainy days were associated with low intensity rainfall of category 0.01 to 3.0 cm per day.

(b) **Intensity of drought and probable moisture deficit of North East India tea growing areas**

From long-term daily evaporation and rainfall data recorded in fifteen different locations in North East India scattered over various tea districts in South and North Bank of Assam, Cachar, Dooars and Darjeeling, the probable moisture deficit during November to March was calculated adopting book keeping method and intensity of drought in different tea districts was delineated on a map. The map will be published soon. Between 150 to 300 mm probable deficit over 5 months period (i.e., higher drought intensities) seemed to be experienced by Terai, Western Dooars, Goalpara, North Kamrup, Cachar, Nowgong, Golaghat and Mangaldai—Deckiajulie regions of North Bank. However the maximum intensity of drought (250 to 300 mm in 5 months) was shown by Terai/part of Western Dooars, Nowgong and part of North Bank comprising of Deckiajulie/Mangaldai area.

(c) **Meteorological data**

Meteorological observations were carried out throughout the year in seven Class "A" Observatories at Tocklai, Margherita, Thakurbari, Silcoorie, Nagrakata, Gungaram and Nagri-Farm. Summarised data are given in Appendix-D of this report. Besides, total monthly U.S. Pan evaporation data of 13 sites are also given in Appendix-D.

Advisory Soil Analysis

A total of 41,300 soil tests were carried out involving 16124 soil samples (excluding Nagrakata). Samples were sent by the member estates on 664 occasions for the purpose of deciding suitability for extension planting, replacement planting, replanting, nursery and also for evaluation of potash status for the purpose of manuring. Samples were also received from problem areas where either performance of tea was poor or did not survive.

During the course of analysis of these samples where the Managers had reported failure or poor performance it was observed in many cases that the main reasons involving soil factors were (a) adverse soil pH (b) compactness or heavy texture of soil - specially cause of failure for nursery. (c) poor fertility-mainly due to poor organic matter status of the soil. Remedial measures were suggested in the reports. In quite a number of cases re-sampling by adopting proper sampling method helped to detect the exact cause of malady indicating need for more stress on correct sampling.

Highlights

1. *Temperature rather than day length seems to influence bud break in tea. Micro-environment of the rhizosphere affects bud dormancy.*
2. *Efficacy of ethephon at 100 ppm as a spray for temporary crop suppression without affecting the ultimate crop has been confirmed on commercial scale. This may be used as a tool for crop regulation in tea.*
3. *Order of laterals was not found associated with the second flush quality. Growing conditions rather than the type of laterals contribute for the quality.*
4. *Ethephon 1000 ppm, oxyfluorfen 500 ppm and chlormequat 2000 ppm may be used with advantage besides selective centering for lateral promotion in young tea. These chemicals and chlorflurenol methylester, a morphactin, promote branching in nursery grown plants (clone & seedlings) as well. Time and dose vary with the time of planting in field and the clone.*
5. *Drenching spray of the foliage with aqueous solution of auxin (NAA) 10 ppm + cytokinin (kinetin) 10 ppm hastened healing of wounds in the stems of pruned bushes. This may be used as an ameliorative measure against hail damage in tea.*
6. *Shoot water potential (Ψ_s) may be used as a parameter in screening tea varieties for drought tolerance.*
7. *Technique for water culture of tea has been standardised.*

PLANT IMPROVMENT

1. Biclonal Stock Trial

The long-term trial of three biclonal stocks TS 490, TS 491 and TS 492 planted in 1981 at Tocklai was continued during the year. Progenies of all the stocks were found to be vigorous and more or less uniform in their morphological characters. Manufacturing trial will be done when sufficient leaf becomes available.

Three more micro-seed baris, TS 496, TS 497 and TS 506 are expected to yield sufficient seed next season for trial in different districts.

2. Long-Term Trial of Clones

Out of the three long-term trial of clones completed two pruning cycles, eight clones were found to be promising on the basis of yield and quality performance. Cuttings from these clones will be distributed next season in different sub-stations for establishment of nucleus blocks as well as to observe their performance in different agroclimatic region. A few clones are expected to be released in near future.

3. Polyploidy breeding

The production of triploids from hybridization between vigorous tetraploids and high quality diploid clones were reported earlier. (Annual Report 1980-81). A long-term trial with 20 triploid clones obtained from crossing between a tetraploid clone with TV 1, TV 3 and TV 7, was continued. Initial yield records and tasting results indicate a number of clones to be promising.

4. District Selection Scheme

During the year, clonal selection work was undertaken in two estates in the South Bank and six estates in the North Bank, from which 318 bushes were initially selected for trial. Table 5.01 shows the current position of the selection scheme covering Assam and Tripura.

Table 5.01. *Tea estates surveyed and number of bushes selected in Assam and Tripura upto March 1983*

Region	No. of Estates surveyed		Total Area surveyed (ha)		No. of bushes selected	
	1982-83	up-to-date	1982-83	up-to-date	1982-83	up-to-date
Assam						
South Bank	2	52	60.89	1840.21	82	2161
North Bank	6	43	231.32	1971.76	236	1714
Cachar	–	9	–	479.66	–	280
Tripura	–	3	–	118.44	–	90
Total	8	107	292.21	4410.10	318	4245

During the year, the selection team also made 72 visits to the estates to take follow-up measures for schemes undertaken earlier. Altogether 178 clones were put under Long-Term-Trial during the year as shown in Table 5.02.

Table 5.02. *Long-Term-Trial of clones established in the estates during 1982-83.*

Region	Estate	No. of clones under Trial	Date of planting	
Assam				
South Bank	Barpathar	6	May	1982
	Dejoo Valley	13	May	1982
	Dilli	15	December	1982
	Dhoedaam	25	March	1983
	Mukrong	12	November	1982
	Thowra	11	November	1982
North Bank	Seajuli	23	December	1982
Cachar	Borojalinga	11	June	1982
	Lallamookh	9	September	1982
Tripura	Haplongcherra	16	September	1982
	Harendranagar	15	June 1982	
	Meghlibund	22	June 1982	

PLANT PHYSIOLOGY

Seasonal dormancy

Past experience revealed that both short day length and low temperature play important roles in inducing bud dormancy in tea. In order to gain further insight into the mechanism of dormancy in tea, an experiment programming winter and summer combinations of temperature and day length was conducted using potted plants of TV 1 & TV 20 in Conviron Growth Chamber where the desired combination of day

length and temperatures can be programmed. In order to fix the factors responsible for inducing dormancy through elimination process during summer months short day-lengths (9 hrs from 7 a.m. to 4 p.m.) were introduced in combination with high (30° ± 0.5° C day and 20° ± 0.5° C night) temperatures. Whereas in winter months long day-lengths (14 hrs from 4 a.m. to 6 p.m.) in combination with high and low temperature conditions similar to those of summer experiments were set. Humidity was set around 80% in both occasions.

It was observed that short day-length in combination with the average high day/night temperature conditions failed to stop shoot growth during summer months (July to October) and all plants inside and outside (control) the growth chamber completed a flush of growth at the same duration of time. However, short day-length treatment in combination with low day/night temperature conditions stopped bud break and plants were dormant up to end September until the plants were removed to open normal environment. Similarly long day-length in combination with the average low day/night temperature could not induce bud break during winter. But the long day-length treatment with average high day/night temperature conditions induced early bud break by second week of February which was similar to our earlier results of high temperature (28° ± 2° C) effect alone. These results indicate that temperature had an overriding influence on forcing the bud to grow or dormant than the day-length. It will be worth mentioning that it was not possible to break winter dormancy during the deep period (December to January) even keeping the plants under long day and high temperature condition continuously from end summer.

Growth regulators on crop distribution

The principal objective of this experiment was to explore the possibility of increasing the early (first flush and second flush) crop proportionately by spraying various growth promoting substances like gibberellins, auxins, triacontanol etc. The plots were selected and pretreat crop was recorded during cold weather period of 1982 on clone 33/52 in Tocklai division. It was a randomised block design with ten treatments and four repeats of 80 bushes plot size. The first spraying was given on March 18, 1983. The following were the treatments included. GA_3 100 ppm, GA_{4+7} 100 ppm, $GA_3 + GA_{4+7}$ 50 + 50 ppm Miraculan 2.5 ppm, Miraculan 2 ppm, Microbial broth, chlorocholine chloride (CCC) 100 ppm, Paclorobutrazol (PP333) 100 ppm, Naphthalene acetic acid (NAA) 10 ppm and control.

The weekly pluckings were recorded and the response in terms of crop and quality to repeated monthly spraying of these substances was observed. Bud samples from the treated plots [illegible]

tative estimation of growth promoters and inhibitor fractions which might help in understanding the differential response to treatments in seasons and clones.

Growth Regulators for temporary crop suppression

Further to the results reported in Annual Report 1981-82 p.40 and Two & A Bud 28:42-46, 1981 an experiment was taken up on commercial scale in Meleng T.E. using one acre plots of mature TV1 bushes of light pruned tea using ethephon 100 ppm, cycocel 200 ppm and control. The spraying was given on 30th September 1982 and weekly plucking was recorded. It was observed that ethephon at 100 ppm was effective in crop suppression upto 50% while CCC at 200 ppm promoted crop for one week followed by subsequent suppression for 2 weeks. The ultimate crop was not affected, rather a marginal increase upto 18% in case of CCC was effected in treated plots (Table 5.03). Confirmatory commercial scale experiments are planned using different clones in different areas before recommendation as a practice to the industry.

Table 5.03. *Growth Regulators for temporary crop suppression in tea (TV-1 Meleng T.E.) sprayed on 30.9.82 Plot size-one acre.*

Treatments	Crop kg/plot			
	Oct.	Nov.	Dec.	Total
Control	450	296	290	1036
Cycocel 200 ppm.	542	363	317	1222
Ethrel 100 ppm.	429	345	263	1037

Order of laterals on quality of tea

Season and order of laterals during spring are said to contribute for the second flush quality of tea (Annual Report 1981-82, p.47). In order to confirm which one among the two factors, namely the prevailing mild weather conditions during spring or the order of laterals is responsible for the quality factor, an experiment was continued in the Botany plots at Tocklai using TV1 & TV2 plants and pruning the bushes in December, April and August to get the first and second order laterals in spring, summer and fall during the year 1982. Tea was manufactured and evaluated for quality throughout the year. The taster's evaluations as influenced by pruning time and crop in different seasons are given in table 5.04 below—

Table 5.04. *Seasonal influence on quality of made tea.*

Seasons / Pruning time	Spring	Summer	Autumn
December	8.23	8.03	7.97
April	—	7.93	7.91
August	—	—	7.70

Figures in table 5.04 are mean of two tasters for three clones. It is evident that weather parameters prevailing during the spring time for slow balanced growth of shoots are responsible for the second flush quality of tea rather than the order of [illegible]

were produced in autumn by pruning in August, the second flush quality was not evident.

Growth regulators for branching in young tea

Further to the results reported in Tocklai Annual Report 1980-81 p.40, crop was recorded during the year in both Tocklai nursery and Heeleaka T.E. and the bushes were given frame forming prune in the month of December, 1982. The pruning weight and the number of pruning sticks of treated bushes were recorded. Pruning weight and the total crop were found to be positively correlated. The findings on the laterals produced, girth of the main stem, early crop, number of pruning sticks for Teenali 17 in Heeleaka T.E. as influenced by the treatments are given below:

Table 5.05. *Effect of Growth regulators on lateral promotion in young tea. (Heeleaka T.E., Clone Teenali 17).*
Date of planting July 1980. Date of spraying 6.9.80.

Treatments	No. of laterals per bush	Girth of stem mm.	Early crops g/bush	No. of pruning stick/bush	Pruning wt. g/ bush.
Control (Centering)	3.60	7.64	496	7.6	1262
CEPA 1000 ppm	4.47	8.68	552	7.9	1402
CCC 2000 ppm	4.17	8.87	616	7.7	1512
SADH 2000 ppm.	3.98	8.26	513	7.5	1315
Goal 500 ppm.	5.45	7.06	555	8.0	1436
CD at 5%	0.68	1.06	NS	1.31	NS

Although pegging has increased the number of pruning sticks, it has not reflected in the early crop. The treatment CCC 2000 ppm seems to have an edge over others in terms of the early crop. Clones vary in their response. The stage of growth phase of the plants and concentration are crucial for the desired results. Follow up experiments for standardising the concentration and time of application for both seedlings and clones have been taken up in Tocklai as well as in Thowra T.E. and observations are continued.

Ameliorative measures against hail damage
Hastening of wound healing

Hail damage in tea plantations of N.E. India is a recurring feature. In the absence of any method to prevent hailstorm, some ameliorative steps to hasten the healing of wounds were thought of as an interim measure. The effect of certain measures like spraying of copper fungicides, applying indopaste, linseed oil on cut wounds was also observed. Spraying of sucrose is also reported to help the callusing. For rapid callusing and wound healing a balance between auxin and cytokinin is essential in addition to the nutrients. With this background an experiment was initiated with spraying of the canopy with different combinations of growth regulators like auxins and cytokinin, sucrose, copper fungicides swabbing the wounds with indopaste, linseed oil etc. in mature bushes of TV1, TV2 and TV7. Wounds similar to hail damage on the bark was simulated with cork borers. The effect of these treatments on initiation of callusing, and percentage healing of the wounds were calculated and the data are presented in Table 5.06.

Table 5.06. *Wound healing as influenced by different ameliorative measures.*

Treatments	Mean % of healing at end of 3 months.			
	TV 1	TV 2	TV 7	Mean
1. Control	60	54	54	56d
2. NAA 10 ppm + BA 10 ppm.	82	80	83	82a
3. NAA 10 ppm + BA 20 ppm.	80	79	78	79b
4. NAA 10 ppm + BA 10ppm + Cu (0.25%)	78	81	81	80b
5. NAA 10 ppm + BA 10ppm + Sucrose 1%	71	72	76	73c
6. Cu 0.25%	55	50	64	56d
7. Linseed oil	55	64	43	54d
8. Indopaste	23	24	27	24e

The treatment with different superscripts are significantly different at 5% probability. The figures are the mean of five observations.

There was no perceptible difference in response between clones. Spraying of the canopy with an aqueous solution of Naphthalene acetic acid (NAA) at 10 ppm along with Benzyl adenine (BA) at 10 ppm, hastened healing of wounds. There was no advantage of increasing the concentration of cytokinin or addition of sucrose in the spray solution. Wounds in smaller sticks heal faster than those in trunk or larger stumps. Spraying of copper and application of linseed oil delayed the callusing and healing process, while indopaste inhibited the process (Table 5·06 & 5.07).

Table 5.07. *Wound healing as influenced by size of the stem.*

Treatments	% healing of wound		
	Lateral stem	Trunk	Mean
Control	67	32	49d
NAA 10ppm + BA10 ppm.	85	45	65a
NAA 10 ppm + BA 20 ppm.	82	40	61b
NAA 10ppm + BA 10 ppm + Cu (0·25%)	78	42	60b
NAA 10 ppm + BA 10 ppm + Sucrose 1%	73	36	55c
Cu 0.25%	59	31	45e
Linseed Oil	62	34	48d
Indopaste	27	28	27f

Figures with different superscripts are distinctly different at 5% probability.

Follow up work for confirmation will be taken up during the year 1983.

Time and severity of pruning on recovery of bushes

Based on the starch content in roots and direction of movement of photosynthates from the maintenance

leaves, Dec.-Jan. has been adjudged as the ideal time for pruning the bushes. In order to schedule the pruning practices MP, LP, DS etc. in commercial scale, a knowledge on recovery of the bushes, bud break, time taken for reaching the tipping level and impact on the early crop is required. With this objective, an experiment was initiated with MP, LP & DS pruning in mid Dec. mid Jan. and mid Feb. Scoring was done for starch in roots. The treatments were given on two clones 16/10/8 and 1/7/1 during the cold weather of 1982-83 and the observations are continued.

Seasonal trend in level of starch

Root samples from the three clones TV1, TV20 and 3/29 having different leaf pose, were collected every month throughout the year and starch was analysed quantitatively. The percent starch level on dry weight basis is shown in Table 5.08.

Table 5.08. *Seasonal trend in starch level in three clones.*

Months	Clone		
	TV1	TV20	3/29
January	16.23	17.18	14.52
February	11.40	11.70	12.01
March	9.75	8.81	8.25
April	9.60	7.26	8.94
May	7.20	5.22	6.60
June	6.96	7.56	8.40
July	6.12	9.12	8.40
August	3.96	4.64	5.12
September	3.56	4.88	5.47
October	5.20	6.13	5.55
November	7.08	7.20	7.20
December	8.10	8.12	8.46

Importance of maintenance leaves : Field studies

In order to study the importance of different layers of the maintenance canopy on productivity of the bushes, an experiment was started in Tocklai (Botany) plots, on 15 years old TV7, TV15 and TV18 plants representing China, Assam and Cambod types. As the leaf pose in these types are different, optimum thickness of the canopy is likely to vary. Once an optimum leaf area and thickness of the canopy is determined, the management practices like tipping height etc. can be devised. The canopy was divided into 10 cm thickness and different thickness as well as positions were designed during beginning of the year, on both pruned and unpruned bushes of the clones. Weekly pluckings were recorded and the effect of the canopy thickness on the crop produced was evaluated.

The topmost layer of 10 cm of the canopy is essential and accounts for 75% of the crop. Addition of another 10 cm (mid layer) improves the crop marginally. The role of bottom 10 cm on productivity was not perceptible. It might contribute for the build up of reserve and maintenance of root respiration, rather than for productivity.

Screening parameter for drought tolerance

The plant water status measured in terms of shoot water potential (Ψs) in bars can be used as a screening parameter for selection of drought tolerant varieties. (Tocklai Ann. Report 1981-82 p. 46, 47). In order to extend the information for field application of screening the plant materials, further refinement and standardisation of the technique (sampling) was attempted.

Banjhi versus growing shoots, one and a bud, two and a bud, three and a bud and four and a bud were compared as material for shoot water potential measurement. Shoots were sampled both from the periphery as well as centre of the canopy. It was found that growing shoots of 2 + Bud and 3 + Bud can be used safely as representative sample compared to the banjhi shoots and growing 1 + Bud. Shoots in the periphery of the canopy and banjhi shoots should be avoided in sampling.

Water Culture of tea

For nutrient physiology and photosynthetic studies, water culture of tea was thought to be essential to create standard conditions. As a first step in this direction, the technique of growing tea in water mediuln requires to be standardised as earlier attempts in 1976 and 1978 ran into difficulties in establishing the plants in water culture.

As success of water culture depends on proper aeration, maintenance of optimum pH and nutrients strength of the medium, standardisation of these aspects were taken up during the year using Stock 449 seedlings, adopting 1/3 strength of Hewitt's solution as modified by Sri Lanka researchers. It has been found that tea plants can be grown without any adverse effects in liquid media during cold season maintaining proper aeration at pH 5 under cold weak light conditions with 1/3 concentration of Hewitt's nutrient solution. Alternation of root and shoot growth was clearly visible. During the year, Hewitt's modified solution and California solution by Epstein for water culture were compared. The latter seems to be better, where no deficiency or casuality of plants occurred. Interestingly, water culture tea plants were growing in winter months without any dormancy (fig. 5.01.) The plants completed three flushes from October-February. Temperature of the rhizosphere might play a role in bud dormancy. In addition to the water culture, nutrient film technique (NFT) for growing tea plants without soil is tried which has met with initial success. Both water culture and NFT are pursued for refinement and standardisation.

Plant Protection (Entomology)

Highlights

Oviposition and fecundity of pink and scarlet mites vary in different clones and at different temperature regimes. Tea on southern slopes in general and unshaded southern slopes in particular suffers more from termite and Poria *attack. Plictran (Cyhexatin) shows promise as an acaricide. Dicofol and Ethion have translaminar effect on pink and purple mites. Two novel chemicals synthesized by NCL show acaricidal property. Aldicarb gives effective control of red spider on young tea. Some granular insecticides are recorded as good termiticides. X-factor (Iota isomer of BHC) is found to be a termiticide for control of mound building termite. Dimilin, the chitin inhibitor, is effective against loopers. Few predatory mites have been recorded from tea pest complex.*

Mite Pest

Pink mite, *Acaphylla theae* (Keifer) : Fecundity and life-cycle on different clones

Ovipositing response of pink mite on Tocklai clones TV1 to TV24 at 20 & 25° C, 75-80% R.H. using leaf-disc method was assessed. On five leaf-discs of each clone, fecund female was placed for egg-laying and the rate was monitored at 24 hours intervals.

Oviposition period varied between 7 and 18 days on different clones; at 25°C highest number of eggs (18.4) were on TV1 during an oviposition period of 12 days, and the lowest number (12) on TV22. At 20°C highest number of eggs (15.6) were laid on clone TV24 followed by TV1 (15.4) during an oviposition period of 14.2 and 14.0 days respectively while the lowest number of eggs (11.6) were laid on TV2 (Table 6.01)

Table 6.01. *Effect of temperature on oviposition of Pink mite* (Acaphylla theae (*Watt*) *Keifer*).

Clone	25°C		20°C	
	Mean egg laying/mite	Mean oviposition period (days)	Mean egg laying/mite	Mean oviposition period (days)
TV1	18.4	12	15.4	14.0
TV2	14.0	12	11.6	13.6
TV3	15.0	12	13.8	13.6
TV4	16.4	13	14.2	15.6
TV5	17.0	12	14.8	15.0
TV6	14 0	13	12.6	13.6
TV7	16.0	11	14.0	13.0
TV8	14.0	11	12.4	12.8
TV9	14.0	11	12.8	11.2
TV10	15.0	12	13.4	12.0
TV11	16.0	12	14.0	11.2
TV12	14.0	12	13.4	12.6
TV13	15.0	14	14.0	12.8
TV14	14.0	13	14.2	13.8
TV15	13.0	12	14.0	12.6
TV16	14.0	12	12.6	10.2
TV17	14.0	14	14.0	13.4
TV18	14.0	13	15.0	13.4
TV19	14.0	12	14.8	12.6
TV20	14.0	15	14.2	12.8
TV21	14.0	13	13.6	13.6
TV22	21.0	12	13.8	13.2
TV23	13.0	13	13.6	12.2
TV24	15.0	14	15.6	14.2

Incubation period was short (3.7 to 4 days) on TV5, TV7, TV13, TV22 and TV24 at 25°C and relatively longer (4.9 days) on TV15. At 20°C the incubation was delayed; the minimum being 6.0 days on TV1 and TV24 and maximum being 7.2 days on TV20 (Table 6.02).

Table 6.02. *Effect of temperature on incubation period and life-cycle of Pink mite* (Acaphylla theae (*Watt*) *Keifer*).

Clones	25°C			20°C		
	Incubation period (days)	Duration of immature stage (days)	Duration of life-cycle (days)	Incubation period (days)	Duration of immature stage (days)	Duration of life-cycle (days)
TV1	4.4	4.0	8.4	6.0	6.1	12.1
TV2	4.6	4.4	9.0	6.6	6.2	12.8
TV3	4.2	4.3	8.5	6.7	6.3	13.0
TV4	4.5	4.3	8.8	6.7	6.3	13.0
TV5	4.0	4.1	8.1	6.4	6.2	12.6
TV6	4.6	4.1	8.7	6.2	6.2	12.4
TV7	4.0	4.2	8.2	6.1	6.2	12.3
TV8	4.3	4.1	8.4	6.3	6.2	12.5
TV9	4.3	4.0	8.3	6.4	6.3	12.7
TV10	4.3	4.2	8.5	6.5	6.3	12.8
TV11	4.3	4.0	8.3	6.3	6.2	12.5
TV12	4.3	4.0	8.3	6.3	6.2	12.5
TV13	4·0	4·0	8.0	6.2	6.0	12.2
TV14	4.6	4.3	8.9	6.2	6.0	12.7
TV15	4 9	4.4	9.3	6.2	6.5	12.7
TV16	4.3	4.3	8.6	6.2	6.4	12.6
TV17	4.3	4.2	8.5	6.4	6.2	12.6
TV18	4.4	4.1	8.5	6.2	6.1	12.3
TV19	4·7	4.2	8.9	6.2	6.3	12.5
TV20	4.7	4.3	9.0	7.2	6.3	13.6
TV21	4.8	4.4	9.2	6.3	6.5	12.8
TV22	4.0	4.2	8.2	7.0	6.4	13.4
TV23	4.6	4.3	8.9	6.3	6.5	12.8
TV24	3.7	4.1	7.8	6.0	6.1	12.1

At 25°C the duration of immature stages is 4 days on TV1, 9, 11, 12 and 13, while on TV2 to TV8, TV10 and TV14 to TV24 4.1 to 4.4 days are required for maturity, but at 20° C the total duration of immature stages on clones TV1 to TV24 varied between 6.0 to 7.2 days (Table 6.02). The variation in the fecundity and life-cycle may be attributed to the interaction of temperature and clonal character.

Scarlet mite, *Brevipalpus phoenicis* (Geijskes): life-cycle and fecundity on different clones

Studies on oviposition response of scarlet mite on TV1 to TV5 at 25° C, and TV1 to TV5 and TV21 to TV24 at 20° C and 75-80% R.H. were made. Results of the studies on TV6 to TV24 at 25° C, and TV6 to TV20 at 20° C were reported in 1982. Oviposition period varied between 12.0 to 17.4 days on TV1 to TV5 at 25° C, highest number of eggs (6.6) were laid on TV1 during an oviposition period of 17.4 days and the lowest number (4.4) on TV5 during an oviposition period of 14.0 days. On TV3 and TV4 during an oviposition period of 12.0 - 13.0 days 4.8 eggs were laid. At 20°C highest number of eggs (4.0) were laid on TV1 to TV4 and TV24 during an oviposition period of 17.4 to 22

days. While the lowest number of eggs (3.0) were laid on TV5 (Table 6.03).

Table 6.03. *Effect of temperature on oviposition of Scarlet mite* (Brevipalpus phoenicis (*Geijskes*).

Clone	25°C		20°C	
	Mean egg laying/mite	Mean oviposition period (days)	Mean egg laying/mite	Mean oviposition period (days)
TV1	6.6	17.4	4.0	22.0
TV2	5.2	13.6	4.0	17.4
TV3	4.8	12.0	4.0	18.0
TV4	4.8	13.0	4.0	18.0
TV5	4.4	14.0	3.0	16.8
TV21	—	—	3.2	16.6
TV22	—	—	3.6	21.8
TV23	—	—	3.4	21.2
TV24	—	—	4.0	21.4

In a second series, the life-cycle and incubation period of the mite on TV1 to TV24 at 20° C and TV1 to TV5 and TV21 to TV24 at 25° C were studied. Studies on TV6 to TV20 at 25° C have been completed earlier (1982).

Incubation period was short (6.0 days) on TV1 and longer (7.5 days) on TV5 at 25°C. At 20°C the incubation period was delayed; the minimum being 19.2 days on TV20 and maximum being 23.5 days on TV11.

At 25° C the duration of life-cycle is 27·5 days on TV5 and 24.0 days on TV1 while at 20° C the duration of life-cycle is 52.4 days on TV17 and 46.3 days on TV5 and TV12 (Table 6.04).

Table 6.04. *Effect of temperature on incubation period and life-cycle of Scarlet mite* (Brevipalpus phoenicis (*Geijskes*)

Clone	20°C		25°C	
	Mean incubation period (days)	Mean duration of life-cycle (days)	Mean incubation period (days)	Mean duration of life-cycle (days)
TV1	22.1	48.1	6.0	24.0
TV2	21.9	47.9	7.0	25.4
TV3	22.3	48.3	7.0	27.2
TV4	21.3	47.3	7.0	26.0
TV5	21.3	46.3	7.5	27.5
TV6	22.6	49.6		
TV7	21.5	46.5		
TV8	21.3	47.3		
TV9	20.8	47.8		
TV10	23.1	51.1		
TV11	23.5	49.5		
TV12	22.3	46.3		
TV13	22.1	47.1		
TV14	21.5	49.5		
TV15	21.6	50.1		
TV16	22.7	51.7		
TV17	23.4	52.4		
TV18	22.7	50.7		
TV19	23.1	52.1		
TV20	19.2	47.2		
TV21	22.7	51.7	7.0	25.0
TV22	22.5	50.5	7.0	25.0
TV23	22.2	50.2	8.5	27.1
TV24	20.7	46.7	7.0	25.0

Termites

Incidence of termite on hot and cold slopes of Cachar

To study the distribution pattern of termites on different slopes a series of further observations were taken in the Cachar gardens to confirm the earlier findings (Ann. Rep. 1980-81). Observations were taken from six estates on South and North slopes irrespective of shade status. In southern slopes, shade status is always poor. 100 mature tea bushes (Assam jats) in four groups of 25 bushes each were examined. The rating was done as 0 =no infestation, 1 = slight, 2 =moderate, 3 = severe an 4 =very severe.

The termite species involved were *Odontotermes* sp, *Microcerotermes* sp and *Neotermes* sp.

From the results it is found that the cold slopes (North slopes) have less termite activity and the lowest degree of termite attack on the hot slope (South slope) exceeded the highest degree of termite attack in the cold slope.

Further observations were made on the intensity of termite attack and of *Poria* in the well-shaded and unshaded hot slopes to correlate *Poria* infection with termite attack. The results (Table 6.05) show that *Poria* infection accompanied by termite attack is more on the unshaded hot slope than in the shaded hot slope. As such, build up of termite attack could possibly be reduced in hot slopes by growing a good stand of shade. This will help to give protection to tea bushes against sunscorch, debilitation, etc. on hot slopes.

Table 6.05. *Infestation indices of termite and Poria per bush on shaded and unshaded Southern slopes of Cachar tillahs.*

Estate	Termite		Poria	
	Shaded	Unshaded	Shaded	Unshaded
1	0.33	1.05	0.28	0.41
2	0.63	1.11	0.35	0.51
3	0.64	1.22	0.37	0.68
4	0.54	1.44	0.34	0.50
5	0.79	1.59	0.35	0.68
6	0.69	1.23	0.40	0.66

Recovery of loss in yield by termite control

Experiments were laid out in a tea estate in Jorhat area to control termite attack and to see how long it takes to recover the crop loss in termite affected bushes.

The pesticides were applied in cold weather of 1980 and yield records were taken at weekly intervals from August '81 to November '81 and June '82 to October '82. The insecticide-treated plot had 700 bushes and an identical plot was kept as control which received no treatment.

Though initially there was some difference in the yield in both the plots in two years, there was gradual trend of increase in crop in the treated plots indicating improvement in growth and vigour of the bushes.

Sap feeders

Clonal susceptibility to thrips and jassid

Observations on the susceptibility of clones TV1 to TV19 to thrips and jassid attack were further continued from April to December. TV1 and TV11 were more susceptible to thrips attack followed by TV18, TV19 and TV2; TV8 and TV9 being least susceptible. But in case of jassids TV18, TV8, TV9 and TV1 were more susceptible; the least being TV6.

The peak period of thrips and jassid incidence was found to be July and August. Thrips has preference for clones in general. These observations corroborate our earlier observations.

Evaluation of Pesticides

Mite control : Field studies

Plictran 50 W (Cyhexatin containing tricyclohexytin hydroxide as active ingredient) at 1:160, 1:200, 1:300 and 1:400; Four Star Wet Sulf at 1:100, 1:150 and 1:200 and Fosmite 50 EC and Novathion 50 EC at 1:200 were evaluated against red spider using low volume sprayers. After four weeks of treatment 98-100% control of the mite was obtained with all the treatments.

In another field trial, Plictran 50 WP at 0.40 kg a.i. /ha (1:500), 0.20 kg a.i./ha (1:1000) and 0.08 kg a.i./ha (1:2500) was sprayed with a high volume sprayer against red spider. Ethion, Dicofol and Tetradifon were sprayed as standard acaricides. After four weeks Plictran gave 95-100% control of the mite. The standard acaricides also gave similar control (Table 6.06).

Plictran at the above three concentrations were evaluated as an ovicide against red spider eggs obtained from laboratory-cultured female mites. At higher concentration, i.e. 0.02% a.i., 18% kill of eggs was recorded, mortality of eggs was less (7 to 11%) in other two concentrations.

Screening of novel acaricides

Six new chemicals synthesized indigenously in National Chemical Laboratory, Poona were sent to our laboratory for evaluation against red spider mite. These products were coded as PAEE, TRE, DCIPRE, pBPRE, OCIPRE and mPBRE. Acetone was used as a solvent. The concentrations in which the chemicals were used and the mortality of red spider with these products are shown in Table 6.07.

Table 6.07. *Evaluation of novel acaricides against Red spider mite,* Oligonychus coffeae *Nietner.*

Treatments	% kill at 48 hours
PAEE at 0.01%	30.1
PAEE at 0.05%	98.1
TRE at 0.01%	65.1
TRE at 0.05%	79.9
DCIPRE at 0.01%	30.1
DCIPRE at 0.05%	73.9
pBPRE at 0.01%	20.0
pBPRE at 0.05%	100.0
OCIPRE at 0.01%	17.8
OCIPRE at 0.05%	80.0
mPBRE at 0.01%	55.8
mPBRE at 0.05%	57.3
Acetone	3.3
Tedion at 1:400	100.0
Control	1.2

Table 6.06. *Comparative efficacies of few acaricides on red spider mite,* Oligonychus coffeae *Nietner (Mean population of 50 leaves)*

Treatments	Dilution	1 week		2 weeks		4 weeks	
		Population	% reduction over control	Population	% reduction over control	Population	% reduction over control
A. Plictran 50 W	1 : 2500	51.0	86.51	15.0	95.89	13.8	95.40
B. -do-	1 : 1000	47.0	87.57	7.8	97.86	2.8	99.07
C. -do-	1 : 500	12.5	96.69	1.8	99.50	0.0	100.00
D. Tafethion 50 EC	1 : 400	5.8	98.47	0.5	99.86	0.0	100.00
E. Delcofol 18.5 EC	1 : 400	2.3	99.39	0.0	100.00	0 0	100.00
F. Tedion V-18 EC	1 : 400	34.0	91.00	0.0	100.00	0.0	100.00
G. Control (untreated)	—	378.0	—	365.0	—	300.3	—
L.S.D. (P=0.05)	—	30.2	—	29.1	—	44.8	—
C.V. %	—	26.9	—	35.3	—	66.8	—

Mite control: Laboratory studies

Laboratory evaluation of Plictran 50 W was carried out at toxic levels 0.0125% a.i. (1:4000), 0.015% a.i. (1:3000) and 0.02% a.i. (1:2500) and compared with Dicofol 18.5 EC at 1:400. Spraying was done using an air-brush sprayer for control of active stages of red spider. The results showed that Plictran at 0.015% and 0.02% concentrations gave 95 and 100% mortality of red spider respectively 96 hours after exposure to the chemical.

Among all these products pBPRE at 0.05% concentration gave the best result, followed by PAEE at 0.05%. However, these two chemicals at lower concentration gave unsatisfactory kill of red spider. The other chemicals in both the concentrations were less effective than these two products.

Systemic granular insecticides as acaricides

Some granular insecticides had been evaluated as acaricides in young tea and was reported in the Ann. Rep. 1981-82. These formulations were tried this year at lower doses.

Furadan, Thimet and Temik were applied to young tea (2 yrs. old TV18 clone) at two doses each: 1 g and 2 g per plant. Furadan was found to be least effective and Temik at 2 g per plant gave the highest control (99.6%) of red spider. Thimet at 2 g per plant gave 80.8% kill of red spider. But, three weeks after treatment the build up of red spider population in all the plots except those which received Temik 2 g per plant was high and immediate spraying had to be done with an acaricide.

Translaminar translocation of Dicofol and Ethion against tea mites

To study the local systemic action of Dicofol (Kelthane) and Ethion against pink, purple and scarlet mite a series of laboratory and field experiments was carried out. The acaricides were sprayed with a high volume sprayer taking care to direct the spray deposit on the upper surface of the leaves infested with pink, purple and scarlet mites and the kill was compared with leaves which received spray on both the surfaces.

The results (Fig. 6.01) show that in case of pink and purple mites, both surface spraying has little more mortality of mites than with spraying the upper surface only. However, these acaricides when sprayed on upper surface of leaves, have little translaminar effect against scarlet mite.

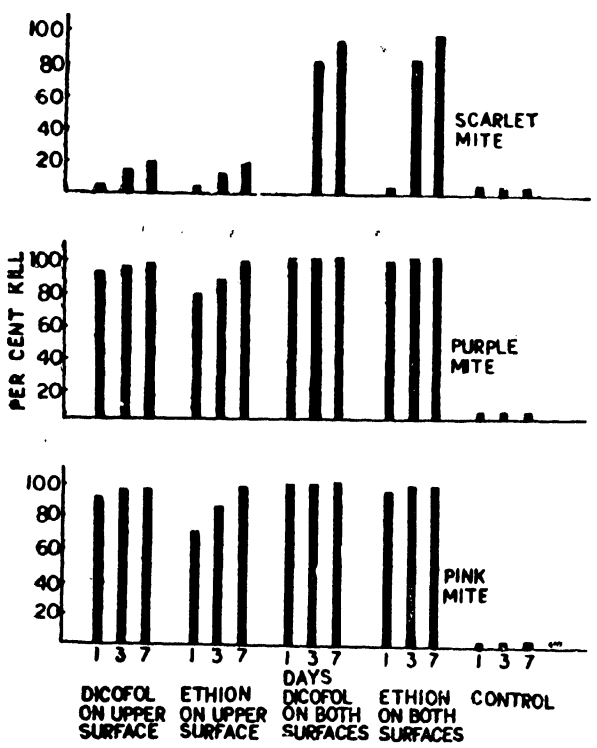


Fig 6.01. Translaminar effect of Dicofol and Ethion on pink, purple and scarlet mites

Thrips control

In a thrips control experiment, Ekalux, Nuvacron and Thiodan were sprayed at 750 ml in 200 litres of water using a power sprayer. These three insecticides, Anthio and Ekatin were also sprayed at conventional dilution of 1:200. A second round of application was done ten days after the first. Population of thrips was noted on ten shoots randomly selected from each plot, each shoot consisted of two leaves and the bud. The results are presented in Table 6.08.

Ekalux, Nuvacron and Thiodan at 750 ml per 200 litres of water gave 99.1, 94.7 and 92% control of thrips respectively a fortnight after the second round. However, at higher concentration 100% kill was recorded with these chemicals. Anthio and Ekatin at 1:200 coal l control 91.2 and 96.5% of the pest respectively.

Jassid control

Three field trials were carried out with Malatox 50 EC, Ekatin 25 EC and Anthio 50 EC at a dilution of 1 litre of chemical in 200 litres of water; Ekalux EC 25, Nuvacron and Thiodan 35 EC at a dilution of 750 ml of chemical in 200 litres of water and 1 litre of chemical in 200 litres of water and a synthetic pyrethroid Decis 2.8 EC at 1 litre of chemical in 4000 litres of water.

In the first trial three applications were made at weekly intervals, in the second trial three applications were made at 2 weeks interval and in the third trial three applications were done at 21 days interval. Observations were continued upto 3 weeks after the third round of spraying in all the trials.

In the first trial, only Thiodan at 1:200 and Decis at 1:4000 gave more than 80% reduction of population after 3 weeks of third treatment.

In the second set of trial, which received treatment at 2 weeks interval, Ekatin, Ekalux (1:200), Nuvacron Anthio and Thiodan gave 100% reduction of population. Malatox, Decis and Ekalux (0.75 lit in 200 lit) gave 84-92% reduction of population.

In the third set of trial, which received treatment at 21 days interval, except Ekalux (0.75 lit in 200 lit) and Anthio (1:200) all other chemicals gave 90-96% reduction. However, Ekalux at lower dose and Anthio gave 87 and 84% reduction respectively.

Termite control

Two sets of field trials to evaluate the efficacy of Thiodan 35 EC, Thiodan 4% dust, Furadan 3 G, Thimet 10 G and Temik 10 G against live wood-eating termites were taken up.

Thiodan 35% EC was applied to the soil around the bushes after slight forking while the dust and granular formulations were placed in a ring around the bushes 15 cm away from the centre, covered with soil and sprinkled with water. Thiodan 35% EC was used at dilutions 1:300 and 1:500 and granular pesticides at 5 g and 10 g per bush. Prior to the application of insecticides dead and decaying branches were removed from the bushes. The earth-runs were also removed.

In the first trial although all the insecticides were found to be superior to control, Thimet @ 5 g and 10 g

Table 6.08. *Efficacies of insecticides at conventional and lower doses sprayed against tea thrips. (Population per 10 shoots, each shoot with two leaves and a bud)*

Treatments (dilution in parts of water V/V)	Observation after 1st spray				Observation after 2nd spray					
	3 days		7 days		3 days		7 days		15 days	
	Population	% reduction over control	Population	% reduction over control	Population	% reduction over control	Population	% reduction over control	Population	% reduction over control
Ekalux EC 25 0.750:200	5.5	76.9	10.0	62.9	3.5	87.0	3.5	87.0	0.3	99.1
Ekalux EC 25 1:200	0.0	100.0	9.5	64.5	2.5	90.7	1.0	97.1	0.0	100.0
Nuvacron 0.750:200	8.0	65.2	11.8	56.1	3.8	86.1	2.0	94.2	1.5	94.7
Nuvacron 1:200	5.3	77.2	5.3	80.4	0.8	97.2	0.8	97.8	0.0	100.0
Thiodan 35 EC 0.750:200	6.5	71.7	17.5	34.6	3.5	87.0	7.8	77.4	2.3	92.0
Thiodan 35 EC 1:200	1.3	94.6	15.8	41.1	1.8	93.5	2.5	92.4	0.0	100.0
Anthio 25 EC 1 :200	3.5	84.8	11.8	56.1	9.3	65.7	4.5	86.9	2.5	91.2
Ekatin 25 EC 1: 200	6.0	73.9	19.3	28.8	8.3	69.4	2.0	94.2	1.0	96.5
Control	23.0		26.8		27.0		34.3			
L.S.D.(P=0.05)		1.52	3.85			1.77		0.92		0.68
C.V. %		15.10	51.60			19.9		30.50		53.00

and Temik @ 10 g per plant were found to be superior to the rest of the insecticides (Table 6.09).

Table 6.09. *Efficacy of few insecticides against live wood-eating termite* Microcerotermes *sp.*

Insecticides	Dilution/ Rate	Degree of infestation/ bush		% reduction over control after 1 yr	
		Trial I	Trial II	Trial I	Trial II
Thiodan 35% EC	1:300	0.36	0.72	81.7	65.9
"	1:500	0.50	1.24	71.4	41.2
Thiodan 4% dust	5 g/plant	0.59	0.63	69.4	70.1
"	10 g/plant	0.42	0.53	78.6	74.9
Furadan 3 G	5 g/plant	0.48	0.97	75.4	54.0
"	10 g/plant	0.33	0.76	82.9	63.9
Thimet 10G	5 g/plant	0.15	0.78	92.1	63.0
"	10 g/plant	0.23	0.58	88.3	72.5
Temik 10G	5 g/plant	0.48	0.79	75.2	62.6
"	10 g/plant	0.25	0.46	81.3	78.2
Control	10 g/plant	1.95	2.11	—	—
L.S.D.(P=0.05)	—	—	—	0.12	0.24
C.V.%	—	—	—	39.42	50.57

In the second set of experiment almost identical results were obtained.

In another trial, it was found that mulching with material other than straw had a definite effect in reducing the termite attack, mulching followed by application of Thiodan 35 EC gave better control.

Mound building termite

X-factor (Iota isomer of BHC) was tried against mound building termites at different doses depending on the circumference and height of the individual mounds. The encapsulated granules were introduced into the tunnels of the mounds by levelling the top and sufficient water was poured into the tunnels for percolation of the chemical deep into the termite colonies. The levelled top of the mound was then covered with soil. It was observed that for a mound circumference 580 cm, height 100 cm, 130 g of chemical in split doses of 100 g and 30 g at 7 days interval was necessary for effective control of termite. For mounds upto 100 cm circumference and 30 cm height single dose of 20 g of chemical was effective. Observations were continued upto six-months of treatments but there was no regrowth of mound.

Insect Growth Regulator

The efficacy of Dimilin 25 WP as a chitin inhibitor was studied against the caterpillar pests of tea under laboratory conditions (Ann. Rep. 1981-82). After observing encouraging results in the laboratory studies, a field trial was arranged against mixed instar looper caterpillars with dosage rates of 2.5 g/lit of water (500 g/200 lits of water) and 5 g/lit of water (1000 g/200 lits

Table 6.10. *Effect of Dimilin against looper caterpillars (Population per ten bushes).*

Treatments	Pretreatment population	Observation after			
		24 hours		7 days	
		Population	% reduction over pre treatment count	Population	% reduction over pre treatment count
Dimilin 25 WP @ 2.5 g/lit of water	87.3	11.3	80.3	0.7	99.2
Dimilin 25 WP @ 5 g/lit of water	48.0	9.3	87.6	0.7	98.6
Ekalux EC 25 @ 1 lit in 200 lits of water	49.3	11.3	77.0	0.3	99.3
Untreated control	58.7	44.3	24.7	39.3	33.3
L.S.D. (P=P.01)	NS	19.7	—	14.4	—
C.V.%	—	17.3	—	23.4	—

of water). After 24 hours most of the 1st, 2nd and 3rd instar caterpillars were dead, but other instars were found to be lethargic and lost the urge for feeding. Some caterpillars could not even cast their skins, and shrivelling of the body, characteristic of death, was noticed. Results (Table 6.10) showed that within 24 hours the mortality range varied between 80 and 88% of the mixed population of looper caterpillars ; the result is comparable with that of Ekalux. Further field studies are in progress.

Experiment with Duromist Nozzle

Preliminary experiments with the nozzle NMD/D 60450 were carried out to establish its efficacy at different concentrations of pesticides. Field populations of red spider was sprayed with Dicofol at different doses and the mortality was noted.

The results of these experiments show that Dicofol at 1:400 sprayed with Duromist nozzle gives effective control (96.5%) of red spider. However, higher concentrations have slightly better edges over the lower concentration.

The rate of discharge of spray fluid is less in Duromist nozzle than that of the nozzles which were used earlier in high volume sprayers. So, it was thought necessary to establish the spray fluid requirement per hectare of tea under different pruning operations sprayed with duromist nozzle on top hamper only.

These results show that the amount of spray fluid needed per hectare is much more less with Duromist nozzle (about 200 lit) than those for conventional high volume nozzle.

Record of predatory mites

Few species of mites were recorded as predators of scarlet mite. *Tyrophagus putrescentiae* (Schrank), *Typhlodromus gopali* Gupta and *Phytoseius* (*Phytoseius*) *crinitus* Choudhury were found associated with scarlet mites in Tocklai. Two more mite species, *Scheloribates* sp. were found associated with the tea scale, *Fiorinia theae* Green.

Further studies are needed to know their food habit and host-specificity.

Pesticide residues

Wet weather samples of tea leaves sprayed with Plictran 50 W, Dursban 20 EC and dry weather sample of Nuvacron were manufactured and sent to the manufacturing firms of the insecticides for estimation of residues carried over to made tea.

Pesticide tainting

Novathion, Corophos, Coroban and Four Star Wet-Sulf were tested for their tainting effect on made tea.

Quality control

22 samples of insecticides and acaricides received from different tea estates were tested in the laboratory for their bio-efficacy and emulsification standards.

Advisory services

626 soil samples were analysed for eelworm population. 140 pest infested samples of tea and ancillary crops received from different member tea estates were examined and reported.

Assistant Entomologist and senior members of the department visited tea estates in different regions in connection with tea and shade problems, experiments, etc.

Plant Protection (Mycology)

Highlights

Several organic, inorganic and systemic fungicides along with two other derivatives of copper were evaluated against two important diseases of tea, red rust and black rot during the actively growing season. A couple of systemics were studied against black rot towards the end season to study their effect on the disease resurgence next season. Spore dispersal of red rust received special attention. Work on the long term experiment on fumigation and rehabilitation made satisfactory progress. Microbial studies of soils from long term high level NPK manured areas were made.

Red rust

One screening trial was conducted in a 1979 planted double hedge clonal tea area (TV 1) carrying severe infection by the disease. The treatments included one systemic fungicide Topsin M, besides copper preparations. There were two copper carbonates, one formulation with sticker and the other without it and two other copper oxychloride formulations with a recommended product as standard. In addition, there was one untreated control series for comparison. Thus, there were six treatments randomized in five replicates in plots of fifty bushes each. Four rounds were sprayed (between 4.6.82 and 11.8.82) using high volume Bakpak sprayers ; the first two rounds were given at fortnightly interval and the subsequent ones at monthly intervals. The effect of the treatments on disease control was recorded by visual marking of all the bushes using standard (0 4) scale of severity of incidence. The results are given in Table 7.01.

Table 7.01: *Degree of red rust incidence per plot of 50 bushes each (Mean of 5 replicates) and percent improvement of treated plots over untreated control. (All treatments were at 1:400 dilution except Topsin at 1:1000)*

	Treatments	Degree of incidence	% improvement over control
1.	Copper carbonate with sticker	20.0	79.
2.	Copper carbonate without sticker	34.6	63.8
3.	Copper oxychloride (Karnataka)	11.2	88.2
4.	Topsin M	82.6	13.6
5.	Copper oxychloride (standard)	9.4	90.2
6.	Unsprayed control	95.6	—
	C.D. at P=0.05	18.5	—
	C.V.%	33.2	—

Topsin M was the least effective in control of red rust. Copper oxychloride (Karnataka) was the best. Control by copper carbonate was good in case sticker is added. In this trial even the fungicide without sticker gave reasonably high degree of control.

Branch cankers

Hetherto known control was to polish the pruning cuts and indopaste. If any disease progress is noticed, the affected part is excised.

Success of biological control of diseases of this type i.e. dry wood rot fungi by using *Trichoderma* sp. which is adopted in control of *Poria hypobrunnea* in tea. *Trichoderma* is abundant in tea soils and is noted for its antagonistic nature to other fungi. Three species have been isolated and cultured. The metabolites and the fungal mat were macerated and applied to pruning cuts to study its effect in controlling the disease. Comparison will be made with the BINAB-T pellets which have comparable effects.

Black rot

Three field experiments were conducted on control of black rot using different fungicides. Two of these were screening trials carried out during the active regrowth of the fungi while the third one was towards the end of actively growing period.

Trial 1 : This trial, in which all the treatments were identical to those for red rust control trial, was carried out on a mature Betjan tea area carrying moderate to heavy infection. There were six treatments and four replicates on plots of twenty bushes each. The fungicides were applied twice at fortnightly interval (on 24.6.82 and 8.7.82) using high volume Bakpak sprayers. The overall control achieved was assessed by marking individual bushes for degree of infection in 0-4 scale of severity. The results are presented in Table 7.02.

Table 7.02: *Degree of infection by black rot per plot of 20 bushes (mean of 4 replicates) and percent improvement over control. Rate of dilution 1:1000 for Topsin; rest 1:400.*

Treatments	Degree of incidence	% improvement over control
Copper carbonate with sticker	13.50	70.97
Copper carbonate without sticker	13.75	70.43
Copper oxychloride (Karnataka)	5.25	88.71
Topsin M	28.50	38.71
Standard copper oxychloride	2.75	94.09
Unsprayed control	46.50	—
C.D. at P=0.05	8.78	—
C.V. %	31.72	—

This trial also confirmed superiority of copper oxychloride (Karnataka) though this particular brand was no better than the standard copper fungicide. Copper carbonate reduced the disease infection considerably, though Topsin M did not cause any appreciable reduction.

Trial 2 : In this experiment Wet Sulf and Delan were included in addition to those used in Trial 1.

A mature TV1 planted area having moderate to heavy infection was selected. Eight treatments (Table 7.03) were applied in two rounds at fortnightly interval in early July using Bakpak sprayers on plots of 24 bushes each, replicated 5 times. The assessment was made as per our standard method. The results (Table 7.03) confirm the earlier findings in Trial 1.

Table 7.03. *Degree of incidence of black rot per plot of 24 bushes (mean of 5 replicates) and percent improvement over control. All dilutions 1:400 except Topsin (1:1000) and Delan (1:800).*

Treatments	Degree of incidence	% improvement over control
Copper carbonate with sticker	14.6	72.45
Copper carbonate without sticker	33.4	36.98
Copper oxychloride (Karnataka)	7.2	86.42
Topsin M	37.2	29.81
Wet Sulf	31.0	41.51
Standard Copper oxychloride	4.8	90.94
Delan	33 8	36.60
Unsprayed control	53.0	-
C.D. at P=0.05	11.12	-
C.V. %	31.99	—

The performance of fungicides other than copper oxychloride was not encouraging. Control by copper carbonate with sticker was comparable to that obtained in the first trial. However, standard COC gave the best results.

Trial 3 : The trial was aimed at evaluating fungicides known to suppress sclerotial formation in fungi elsewhere. Three experiments were conducted on different locations using three different systemic fungicides; copper oxychloride was one of the treatments for comparison.

Sclerotial suppression by fungicides

Black rot survives unfavourable periods (winter) by forming resting stages, sclerotia. In earlier trials systemic fungicides like Vitavax 75% WP and Delan were found to suppress/inhibit sclerotia. To confirm, three different experiments were laid out.

Trial A : Delan, Vitavax and Copper oxychloride were applied to black rot (*Corticium theae*) affected bushes in two series. In one series two rounds of fungicides were applied at monthly interval in mid-August and mid-September while the other series received the same treatments in mid-September and mid-October. The plants were examined for degree of incidence of the disease in the following season (July 1982) (Table 7.04).

Table 7.04. *Percent black rot control after treatment with unsprayed control as nil (Observed in July' 82).*

Treatments	Dilution	% disease control	
		August September treated	September October treated
Delan	1:800	37	26
Vitavax	1:400	61	29
Copper oxychloride	1:400	73	53
Untreated control	—	—	—

Good control upto 73% of the disease was achieved by applying two rounds of copper fungicide till September.

Trial B

In this trial Plantavax was also applied in addition to the three fungicides used in trial 1. This tea was also affected by *Corticium theae* as in the preceding experiment. However, in this trial fungicides were applied in one round only, either in September to one series or in November to another series. The degree of control of the disease achieved in the following season is shown in Table 7.05 taking infection in the untreated control plots as 100. The scale 0–4 is used for marking individual bushes. The total score divided by the No. of bushes gives average disease incidence. To convert the score into percentage remission of disease, untreated control is computed to have had no reduction of disease at all. (In our trials the effect is observed during the following season after application for residual protection).

Table 7.05. *Percent disease (black rot) control per plot after treatment. Observations were made in July 1982. (Delan at 1:1000 all others at 1:400 dilution).*

Treatments	% disease control	
	September treated	November treated
Delan	42	29
Vitavax	32	28
Copper oxychloride	57	3
Plantavax	25	27
Control	-	—

Even one round of Copper oxychloride caused appreciable reduction of the disease when applied in September i.e. before sclerotial formation commences. The other fungicides have however shown some amount of disease control even in November.

Trial C

This trial was in an area where black rot (*Corticium invisum*) was prevalent. Delan, Vitavax and Copper fungicide were applied in two rounds as in trial A. But here the fungicidal applications were made later in mid-October and November. The degree of control (Table 7.06) recorded in the same way as in the preceding experiments shows that the disease reappearance is the lowest in Vitavax treated plants. It is felt that the fungicide may have specific inhibitory action against black rot caused by *Corticium invisum*. Further study to confirm this observation is in hand.

Table 7.06: *Degree of control of black rot taking infection in untreated control as 100 (all at 1:400 dilution except Delan 1:800)*

Treatments	% disease control
Delan	44
Vitavax	89
Copper oxychloride	49
Control	—

Root rots

Fumigation and Rehabilitation

The experiment was laid out in 1981 (Ann. Rept. 1981-82 : 56-57) to find out if fumigation could be successfully used in areas due for replanting to serve the objective of eliminating primary root diseases as well as the 2 year soil rehabilitation period.

The experiment consists of 3 series marked A, B and C each containing 24 plots in 6 replicates, 3 each in Area 106 & 108. Series A and B were uprooted in 1981, the former will be planted out in 1983 along with series C (to be uprooted in 1983) while the latter was planted out with TV 1, TV 25 and Stock 461 in September/October 1981, that is 3 months after uprooting and incorporation of treatments including fumigation.

The response of the plants in series B to different treatments in the first 6 months were given in our Ann. Rep. 1981-82. This year, the plants were centred in June 1982, and thereafter plucking weights were maintained after the plants reached the standard height. They were further cut across in January 1983. All these records, its pruning weight in June 1982, plucking weight and pruning weight as of January 1983 are given in Table 7.07.

Table 7.08: *Bacteria in million per gram of soil (Mean of 3 replicates)*

Treatments				Shade		No shade	
	N	P	K	Bacteria	Actinomy-cetes	Bacteria	Actino-mycetes
1.	0	0	0	46.6	1.3	72.7	2.7
2.	45	22.5	22.5	39.7	1.7	51.7	1.7
3.	90	45	45	46.1	1.0	7.3	1.3
4.	135	67	67	4.8	1.3	7.0	2.0
5.	*45	22.5	22.5	21.6	2.7	29.3	1.7
6.	*90	45	45	34.1	1.0	7.3	1.0
7.	*135	67	67	2.4	1.0	7.0	1.3
8.	180	90	90	3.6	2.0	9.0	0.7
9.	*180	90	90	8.4	1.7	4.7	1.3
10.	224	112	112	3.2	1.3	5.0	1.0

* half in March and half in July—others receive one dose in March

in bacterial population in the areas treated with higher levels of NPK i.e. 135-67-67 and above in the areas under shade and 90-45-45 and above in the areas without shade. For fungi and Actinomycetes however no definite pattern has emerged.

Mycorrhiza

Cross inoculation studies with the isolated azygospores from around tea plants on to maize and onion were made : Maize was sown in inoculated pots with the azygospores of *Gaigospora gigantea* Gerdemann & Trappe. Maize roots developed the endomycorrhiza in their roots by producing arbuscules.

Table 7.07. *Effect of treatment on plant growth as reflected by pruning weight (June), plucking weight and pruning weight (January) in Kg per plot (Mean of 6 replicates) (Here the data in treatment 1 is taken as 100 for ease of comparison)*

Treatments	Pruning weight June 1982		Plucking weight		Pruning weight January 1983	
	in Kg	Tr. 1 as 100	in Kg	Tr. 1 as 100	in Kg	Tr. 1 as 100
1. Cut stumps, instill SOA, replant in between rows after 3 months	2.854	100.00	0.937	100.00	6.062	100.00
2. Fumigate, replant after 3 months	8.854	310.19	2.510	267 88	14.778	243.78
3. Sub-soil, add well-rotted cattle manure, replant after 3 months	3.359	117.70	0.928	99 04	7.723	127.40
4. Uproot and replant after 3 months	3.568	125.00	1.070	114.19	7.722	127.38
C.D. at P = 0.05	3.56	—	1.05	—	4.56	—
C.V. %	62.08	—	62.68	—	46.87	—

In all the 3 observations, plants from fumigated plots have yielded 2.5 to 3 times more than those receiving other treatments. No beneficial effect of subsoiling and adding cattle manure were noticeable till date.

Microbiology

A preliminary quantitative analysis was undertaken to study the effect of long term NPK manuring of tea soils on the microflora from soils collected from area B 43 where the following doses of NPK manures have been applied since 1940 under shade and no shaded conditions. Treatments are given in Table 7.08.

Composite soil samples were drawn from different treatment plots. Dilution-plate technique was employed for estimation of bacteria, actinomycetes and fungi. For bacteria and actinomycetes Thornton's agar medium was used while for fungi, Potato dextrose agar and Czapek Dox agar media were used. The results given in Table 7.08 indicate that there is a sharp reduction

Mycorrhizal colonisation into tea is restricted to age of root, and soil moisture along with nutritional status. This is true with almost all endotrophic mycorrhiza. To have the inoculum preserved it has to be grown on a host which can harbour the particular species. Maize, onion, lettuce are some of the hosts that can harbour the Gaigosporas. The passage and preservation on another host is called cross inoculation. The infection rate was poor 27-38%. This is perhaps due to the fertility of soil.

Disease forecast studies

Based on the daily spore catches made with Burkard spore trap, and correlating the spore counts with the Meteorological data, the following salient features emerged.

Red rust, optimum inoculum potential development takes place when the weekly average mean temperature of 33°C and above, average mean humidity of 77% and above, rainfall of not over 150-160 mm and mean

sunshine hours not less than 4 per day exist. Red rust spores were trapped in small numbers (90–150 per cubic metre of air) right from 10th March in 1982. Higher build up of inoculum upto 750–1800 per c.m. air was recorded on 26th May 1982 by which time the average mean for one week past was $> 33^{\circ}C$, RH $> 77\%$, sunshine hours > 4. Spraying is most beneficial when commenced after the high inoculum concentration developed. On a small scale non replicated trial the level of control achieved was much higher when timed with the inoculum concentration development. With the present data it is not possible to say anything specific about black rot than that the spore build up and inoculum concentration do not favourably react to longer sunshine hours than a mean of 2 hours week during May.

ADVISORY SERVICES

One hundred fortytwo samples of diseased tea and ancillary crops from member estates were examined and appropriate control measures suggested. About a dozen of water samples were tested for bacterial contamination and advice.

Head, Plant Protection attended Area Scientific Committee and other sub-committee as well as the Scientific Advisory Committee meetings. Members of the department also visited some estates in connection with different diseases and their control.

GENERAL

Mrs S. Devi, Senior Associate Professor, AAU, Department of Botany, Assam Agricultural University has almost completed thesis work on "Air spora studies over tea field with special reference to red rust and black rot of tea plant *Camellia sinensis* (L) O. Kuntze" under supervision of Dr G Satyanarayana, at Tocklai.

Highlights

The amount of amides, mainly theanine, accumulating in the feeder roots of clones TV 1 and TV 9 increased with increasing dose of fertilizer nitrogen and seem to bear inverse relation to yield. The total amount of theanine present in fresh root samples were found to be considerably higher than in the corresponding dried root samples. Observations on the effect of varying fertilizer nitrogen and potash on Tingamira jat *indicate the beneficial effect of potash in bringing down the amount of amides (especially theanine) in the roots.*

The leaf could be stored, without affecting freshness, in highly humidified chambers and at lowered temperature (16°C) for 96 hrs. Covering the leaves with polythene sheets during storage under ambient conditions cut down the loss of moisture and maintained the freshness of leaves for 48 hrs without affecting the chemical wither. The no wither (fresh leaf) CTC teas had higher amount of TF but lower amount of TR as compared to natural-withered CTC teas. The teas were brighter and brisker than the control teas.

Of the various processing combinations tried to make black CTC teas from brownish teas giving TV16 and TV1 clones, hard wither and hard roll gave best results for TV16 while TV1 continued to give brownish teas.

Maximum change in the lipids present in tea shoots was observed to take place during fermentation. Loss of carotenoids also was maximum during fermentation. The four major carotenoids viz β-carotene, violaxanthine, neoxanthine and lutein showed seasonal variation (4 clones studied). The volatile component profiles of unwithered (fresh) and withered-CTC teas showed characteristic differences. Pigment profile analysis of tea cream and the decreamed portions of tea infusion has been compared. The cream fraction had one component of TR-3 and TR-1 while the decreamed fraction had high molecular weight TR-1, another component of TR-3 and TF.

The complex of polyphenol oxidase and peroxidase has been separated. Isozyme pattern of peroxidase and polyphenol oxidase has been observed to be different for different components of the shoots.

A simple chemical test to assess the overall quality of made teas has been tried with reasonable success.

NITROGEN METABOLISM IN TEA

Response of tea bushes to high dose of ammonium nitrogen

The response of tea bushes to nitrogen dose from 100 to 300 kg ha^{-1} was examined in clones TV 1 and TV 9 in Expt. B. 8/1 under different spacings in collaboration with Agronomy Department. Initially for a few years the yield of the crop increased with the progressive increase in the applied nitrogen dose, but after a few years, a gradual decline of yield was noted together with death and debility of some bushes receiving 200 and 300 kg N. Biochemical studies of the shoots and roots had shown very little difference in the uptake of nitrogen in leaf at 200 and 300 kg N doses (Ann. Sci. Rep., T.R.A., Biochemistry Dept., 1979-80). Further studies indicated higher accumulation of amide in the feeder roots receiving 200 and 300 kg N as compared to those in roots receiving 100 kg N (Ann. Sci. Rep., T.R.A., Biochemistry Dept., 1980-81). Further we have observed that the activity of nitrate reductase, the principal enzyme involved in assimilation of nitrogen from soil, declined or limited following the continuous application of high dose of ammonium N (Ann. Sci. Rep., T.R.A., Biochemistry Dept., 1981-82). In the present study attempts have been made to confirm the accumulation of nitrogen in the roots as amide particularly theanine and also to examine similar phenomenon, if any, in Cinnamara clone 33/52 (Area 16, T/10) wherein high doses of fertilizer nitrogen has been applied since 1979. Some of the analytical data are presented in Tables 8.01 and 8.02 and in Fig. 8.01, 8.02 and 8.03.

Table 8.01. *Effect of fertilizer-N on soluble-N, amide-N and theanine contents and yield of tea during the period from June to November, 1982. Each figure for chemical analyses is the average of 7 replications.*

Expt.	Clone	N-dose kg N/ha	Soluble N % dry wt.	Amide N % dry wt.	Theanine % dry wt.	Yield kg/plot
*8/1	TV 1	100	0.762	0.272	2.33	47.87
		200	0.847	0.318	2.82	35.31
		300	0.893	0.350	2.93	23.12
	TV 9	100	0.628	0.252	1.94	62.10
		200	0.841	0.308	2.59	35.73
		300	0.805	0.308	2.74	31.47
**T/10	Cinnamara 33/52	100	0.611	0.239	2.44	51.73
		200	0.701	0.277	2.76	51.77
		300	0.774	0.308	2.84	55.51

* Under 120 × 90 cm^2 spacing

** Values are based on 3 treatments × 6 replications; source of nitrogen is urea.

Table 8.01 shows that soluble N, amide N and theanine (principal amide in tea) content in the feeder roots increased with increased dose of ammonium N from 100 to 300 kg ha^{-1} in clones TV 1 and TV 9. The yield patterns of the crop were different. In clones TV 1 and TV9 crop yield declined with increased dose of applied N, while in clone 33/52 it gradually increased upto 300 kg N. In plants amide accumulation is a detoxification phenomenon for their survival due to excess ammonia, either generated in the plants or accumulated from the external source. In clones TV 1 and TV 9 ammonium N has been applied since 1967, while in clone 33/52 urea has been applied from 1979. Probably in the former case toxicity had already developed and in th latter case the toxic level may not have reached so far. It is also possible that different clones may have varying

degree of tolerance to ammonia or different nitrogen fertilizers have different effect on plants. In any case theanine levels in the feeder roots showed a negative correlation with the crop yield in clones TV 1 and TV 9. But in clone 33/52 yield continues to increase although theanine in the feeder roots went on increasing from 100 to 300 kg N doses. A better picture of relationship between crop yield and theanine levels in fresh feeder roots may be seen from the Figure 8.01. It can be noted that theanine levels at 300 kg N dose in clone 33/52 is much less than the corresponding theanine level in TV 1 and TV 9. (see fresh root Table 8.02) and therefore yeld still increased.

The effect of heat on amides and theanine was examined by drying the feeder roots at 65°C for 24 hr and the results are presented in Table 8.02. Drying causes some degradation of the amide especially in the feeder roots receiving 200 and 300 kg N ha^{-1} in clones TV 1 and TV 9.

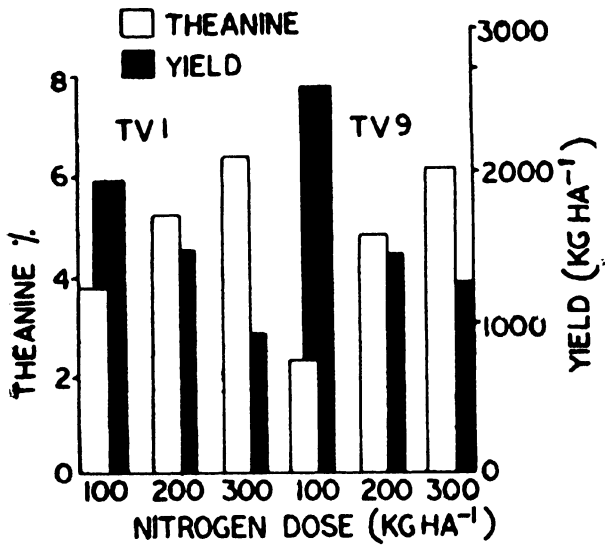


Fig 8.01. Theanine levels in feeder roots and yield of tea.

Table 8.02. *Effect of drying of feeder roots on amide N and theanine content (g/100 g dry wt.), Area 8/1, 120×90 cm² spacing. Each figure is the average of two replications during October and November.*

Clone	Treatment kg N/ha	Amide N		Theanine	
		Fresh root	Dry root	Fresh root	Dry root
TV 1	100	0.271	0.289	3.710	3.140
	200	0.361	0.319	5.125	3.470
	300	0.436	0.330	6.365	3.555
TV 9	100	0.234	0.218	2.385	2.325
	200	0.394	0.272	4.895	2.395
	300	0.402	0.300	5.890	3.350
33/52	100	0.218	0.235	3.151	3.011
	200	0.222	0.250	2.952	3.415
	300	0.259	0.273	4.032	3.616

Amide N of feeder roots shows a seasonal variation (Fig. 8.02 and 8.03), namely increased upto September in clone TV 1 and TV 9 and upto July in clone 33/52. However decrease of amide N was recorded from November.

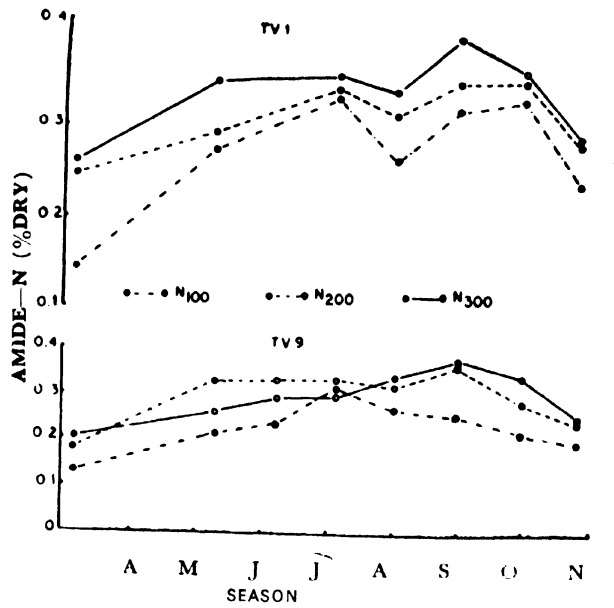


Fig 8.02. Effect of Fertilizer-N on amide-N in feeder roots of clones TV 1 and TV 9. B 8/1.

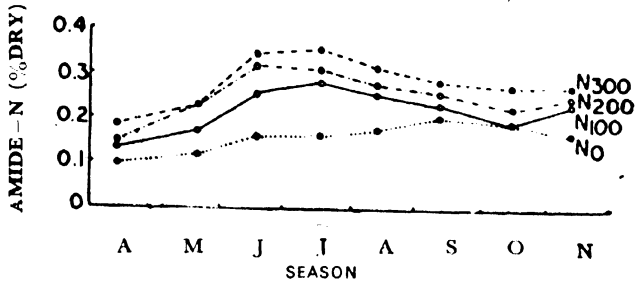


Fig 8.03. Effect of fertilizer-N on amide-N in feeder roots of clone 33/52, T/10.

Effect of potassium on amide concentrations in feeder roots of tea bushes

Our preliminary study in Tingamira *jat* in B 5/1 using 0 and 100 kg K_2O ha^{-1} with 100 and 150kg N ha^{-1} has indicated a controlling effect of potassium on the accumulation of amides, particularly theanine in feeder roots (Table 8·03). Further work using different experimental plots and samples from commercial tea estates is in progress to confirm the observation. This observation appears to have a direct bearing on the yield of tea (Ann. Sci. Rep. T.R.A., 1981–82, p. 19).

Table 8.03. *Effect of potassium on amide-N and theanine content of feeder roots of Tingamira* jat, *Expt B 5/1. Each figure is the average of four treatments during March, 1983.*

Potash dose Kg ha^{-1}	Amide-N %		Theanine %	
	100 N	150 N	100 N	150 N
0	0.390	0.500	7.414	8.246
100	0.258	0.259	3.327	3.504

100 N and 150 N are nitrogen doses per hectare

WITHERING OF TEA LEAF

It was observed (Ann. Rep. 1981–82) that artificial withering of tea leaf preceeded or followed by storage of the leaf during a period of 12 h was short of "chemical wither" achieved in natural withering of the leaf for 12

to 16 h. The storage period was therefore lengthened to study the chemical wither of the leaf as a function of time.

Leaf from mixed jats was subjected to the following treatments :

(1) Natural wither for 16 h (control)
(2) Fresh leaf initially stored and finally withered (s/w) artificially during periods of 16 h and more
(3) Artificial wither of the leaf followed by storage (w/s) during periods of 16 h and more

The withered leaf samples were manufactured by C.T.C. process. Fresh and withered leaf were chemically analysed and the made teas evaluated biochemically.

Seasonal average figures for soluble nitrogen, caffeine, soluble solids in the fresh and withered leaves and TF and TR contents of C.T.C. teas are given in Table 8.04.

Table 8.04. *Chemical wither in artificial wither-cum-storage and storage-cum-artificial wither of tea leaves from mixed jats as a function of time period (seasonal average in percent dry wt.) and its effect on CTC teas.*

Sample		% Soluble nitrogen	% Caffeine	% Soluble solids	% TF	% TR
Fresh leaf		1.89	3.46	48.39		
Natural wither,	16h	2.11	4.16	48.13	1.34	15.26
Store/wither,	16h	2.08	4.26	48.39	1.49	15.61
—do—	18h	2.13	4.47	47.14	1.40	15.72
Wither/store,	16h	2.03	4.12	47.88	1.31	15.65
—do—	18h	2.11	4.30	46.03	1.31	15.52

Chemical wither in terms of increase in caffeine content and breakdown of protein to soluble amino acids (soluble nitrogen) continued with the progress of storage period. Extent of break down of protein during 16 h natural wither could be achieved in store/wither or wither/store for a period of 18 h. The 16 h period is very close to 18 h period so far breakdown of protein is concerned. Hence in artificial withering, storage of the leaf from 16 to 18 hour can be considered as adequate for achieving the requisite chemical wither.

Storage of the leaf prior to artificial withering seems to be beneficial for achieving chemical wither (soluble nitrogen, caffeine) compared to initial withering of the leaf. It is likely that exposure of fresh leaf to hot air blast might adversely affect the biological changes in the leaf. There is however no loss of the total solubles upto 16 h period. Eighteen hour period showed certain loss in the solubles, the loss being slightly more in initial artificial withering system.

In extended period upto 20 h of store/wither and wither/store systems, progressive increase in soluble nitrogen and caffeine content was observed without any effect on the TF and TR content in the corresponding made teas (data not shown).

Storage of tea leaf

During heavy rush of tea leaf when the tea factories cannot cope up with the processing of the incoming leaf, storage of the fresh leaf becomes imperative. In an attempt to see how best fresh leaf could be stored, the following conditions of storage for different periods were tried :

(1) Fresh leaf spread on wire mesh trays, uncovered or covered with polythene sheet, stored in a closed chamber maintained at 80—85% R.H. and at 68°—82°F.
(2) Fresh leaf kept in dish, uncovered or covered with polythene sheet, stored in Germination chamber maintained at 80—85% R.H. with air draught and at 61°F for 9 h (day) with illumination and at 46° F for 15 h (night) in dark.

The effect of storing the leaf under different conditions on chemical changes in the leaf and on C.T.C. teas are given in Table 8.05.

During hot weather it was difficult to maintain the required temperature and humidity in the closed chamber and as a result, the top layers of leaves were drying up with extended periods of storage beyond 16 h. TR content increased with storage period. Sixteen hour storage seemed to achieve the same order of chemical wither as the naturally withered sample. This system of storage was not considered suitable as the evaporation of the surface layers of leaves could not be checked.

In order to check the drying of the surface layers of leaves due to evaporation, the leaves in the trays were covered with polythene sheets and sprinkled with water. Results of covered and uncovered stored leaves are given in Table 8.06.

Although, the temperature and humidity in the closed chamber could not be well maintained, the evaporation

Table 8.05. *Effect of storage under different conditions of tea leaf from mixed jats on chemical changes in the leaf and on C.T.C. teas (average of 3 replication)*

Conditions of storage	Period of storage h	% Moisture	% Soluble nitrogen	% Caffeine	% Soluble solids	% Total oxidisable	% TF	% TR	TF/TR	Valuations Rs/kg A	B	C
No wither (fresh leaf)	0	77.97	1.80	3.68	50.59	30.04						
Natural wither	16	74.38	1.95	3.81	49.09	29.65	1.49	16.72	0.09	8.33	7.00	21.33
(1), Uncovered	16	77.31	2.07	3.80	49.91	31.12	1.37	16.54	0.08	7.50	6.50	21.00
—do—	44	77.02	2.23	4.63	48.45	31.44	1.51	18.41	0.08	8.33	6.33	21.33
—do—	67	74.30	3.10	5.03	47.15	28.76	1.32	17.89	0.08	9.00	7.50	21.10

Table 8.06. *Effect of storage of tea leaf from mixed* Jats, *covered with polythene sheet on chemical changes in the leaf and on C.T.C. teas (average of 3 replications)*

Conditions of storage	Period of storage h	% Moisture	% Soluble nitrogen	% Caffeine	% Soluble solids	% Total oxidisable	% TF	% TR	TF/TR	Valuations Rs/kg A	B	C
No wither (fresh leaf)	0	78.70	1.86	4.25	48.31	31.82						
Natural wither	16	71.99	2.26	5.05	48.48	33.04	1.60	15.65	0.10	8.00	7.50	17.00
(1), Covered	44	77.99	2.37	5.01	47.20	32.33	1.42	16.56	0.09	8.50	6.50	16.75
(1), Uncovered	44	76.16	2.40	4.91	47.25	33.12	1.42	16.53	0.09	8.25	6.50	16.95

in the covered leaves could be checked considerably and the leaves remained in fairly good condition.

For a better control of temperature and humidity throughout the storage period, leaves were stored in a germination chamber as detailed under condition (2) of storage. When the leaves kept on a tray was left uncovered, the drying effect of the top layer persisted probably because of the air draught provided in the system. This could be checked by covering the leaf with polythene sheet. Results of this trial are given in Table 8.07.

Table 8.07. *Effect of storage of leaf from mixed jats in germination chamber on chemical changes in the leaf*

Storage condition	Period of storage, h	% Moisture	% Soluble nitrogen	% Caffeine
No wither (fresh leaf)	0	75.49	2.18	4.23
Natural wither	16	63.84	2.29	4.47
(2), Uncovered	24	74.13	2.22	3.88
—do—	48	70.70	2.27	4.21
—do—	68	68.58	2.38	4.39
No wither (fresh leaf)	0	77.94	1.89	3.44
Natural wither	16	68.30	2.11	4.27
(2), Covered	90	76.29	2.32	4.06

Under accurate control of temperature and humidity and by covering the leaf with polythene sheet it was possible to keep the leaf as fresh even beyond 90 hours of storage. The chemical changes continued with storage period. The effect of such long storage under controlled temperature and humidity on the liquor characters of made tea needs further study. Meanwhile it may be suggested that in a commercial tea factory, when any storage of fresh leaf becomes necessary, the humidified fermentation room can be profitably utilised for storage of the leaf and the leaf should be covered with polythene to check the evaporation. It is expected that the leaf would remain more or less fresh without deterioration.

Withering of tea shoots

Achieving chemical wither is an important step in the manufacture of tea. Several chemical changes have been reported earlier from Tocklai as well as from other tea producing countries. Attaining chemical wither takes about 9—12 hrs. The main objective of the exercise was to enhance or hasten the process of chemical wither so that the leaf is ready for manufacture at a shorter interval of time.

Exposing the leaf to high vacuum for different lengths of time and sudden release to atmospheric conditions was tried without success.

Preliminary experiments in which shoots were subjected to physical pressure and exposing to mild circulation of air was observed to enhance the rate of physical wither as compared to controls.

The rate of loss of weight was monitored as a function of time. The treated leaves were observed to give about 70% withers in about 3 hrs as against 85—80% withers by controls. Teas were manufactured from these treated leaves and the corresponding teas from controls and also overnight naturally withered leaves were also manufactured. From the few comparative reports on the organoleptic assessment of these teas (data not presented) the treatment appeared to have the potential to hasten the process of physical withers at the same time also gave the infusion characteristics usually seen with naturally withered teas. Studies are being continued to standardise the treatment for consistent performance and also follow the chemical changes associated with the treatment. Analysis of chemical parameters associated changes that are likely to give the extent of change and also give certain parameters which can be used as indicators of chemical wither. The work will be continued during 1983—84.

Unwithered C.T.C.

Large scale C.T.C. manufactures of unwithered fresh leaf were carried out in two commercial tea factories using B.C.R. and Rotorvane machines and made tea samples were compared with the usual withered/Rolled C.T.C. teas. In one experiment, the following treatments were done to compare withered and unwithered C.T.C. using B.C.R. and Roll C.T.C. :

(a) Unwithered/BCR/CTC
(b) Withered/BCR/CTC
(c) Unwithered/Roll/CTC
(d) Withered/Roll/CTC (control)

Biochemical and tasters' evaluation of the made teas are given in Table 8.08.

Using Rotorvane machines the following treatments were made in another tea factory :

(a) Unwither/Rotorvane/CTC
(b) Wither/Rotorvane/CTC
(c) Wither/Roll/CTC (control)

Table 8.08. *Biochemical and tasters' evaluations of withered and unwithered C.T.C. teas from mixed jats*

Expt. No.	Processing conditions	% TF	% TR	TF/TR	Tasters' evaluations					
					A	B	C	D	E	F
I	Unwither/ BCR	1.60	10.51	0.15	8	15.00	17.50	6.00	8.00	fair/fair
Rains tea	Wither/ BCR	1.14	12.99	0.09	6	15.00	17.00	7.00	8.50	only fair/ poor
	Unwither/ Roll	1.66	11.93	0.14	8	15.00	19.00	6.00	8.50	only fair/ only fair
	Wither/ Roll	1.35	12.20	0.11	7	15.00	17.50	7.00	8.50	fairly good/fair
II	Unwither/ BCR	2.07	12.91	0.16	7	18.20	17.50	7.00	8.00	fairly good/fair
Rains tea	Wither/ BCR	1.60	15.62	0.10	6	17.40	17.00	7.00	9.00	good/fair
	Unwither/ Roll	2.10	13.63	0.15	8	17.40	18.00	6.00	8.00	good/ fairly good/fairly
	Wither/ Roll	1.65	15.67	0.11	7	17.50	16.50	8.00	8.00	good

Taster A, London panel, scores for liquor
" B & C, Calcutta panel, valuations in Rs/kg
" D & E, Tocklai panel, valuations in Rs/kg
" F, Gauhati panel, scores for strength and quality of liquor respectively

Results of biochemical and tasters' evaluations are given in Table 8.09.

Unwithered C.T.C. teas are brighter and brisker for high TF production but have less body (TR) compared to withered C.T.C. London panel prefers bright, brisk and thin liquor. Calcutta tasters also prefer bright liquor. Tasters preferring body of liquor generally count on withered C.T.C.

Table 8.09. *Biochemical and tasters' evaluations of withered and unwithered C.T.C. teas from mixed jats*

Expt. No.	Processing conditions	% TF	% TR	TF/TR	Tasters' evaluations				
					A	B	D	E	F
I	Unwither/ Rotorvane	2.33	11.43	0.20	7	16.60	8.00	9.00	Poor/only fair
	Wither/ Rotorvane	1.86	13.56	0.14	5	16.60	7.00	8.00	poor/poor
	Wither/Roll	2.31	12.50	0.18	6	16.60	7.00	8.00	poor/only fair
II	Unwither/ Rotorvane	2.23	13.91	0.16	8	17.00	6.00	—	fair/only fair
	Wither/ Roll	1.78	13.77	0.13	6	16.80	7.00	—	fairly good/ only fair

Tasters A, B, D, E & F, same as in Table 8.08.

Fermentation pattern in wither and unwither C.T.C. manufactures was somewhat different. The initial rate of oxidative condensation to TF is higher in unwither manufacture probably because of higher enzyme activity in the unwithered fresh leaf (Ann. Rep. 81—82). The rate of reaction however falls off and unlike withered C.T.C. less of polymerisation to TR occurs resulting in bright and brisk liquor with comparatively less body. In withered C.T.C., the reaction progresses steadily and although comparatively less of TF is formed, TR progressively increases for which more body is formed in the liquor. Since the mode of formation of TF and TR is different in the two systems it is likely that the formation of other constituents partaining to liquor characters may also be different. It is therefore necessary to look into other chemical constituents in unwither C.T.C. teas and their behaviour during storage of the teas.

Blackness of made teas

The black or brown shades of made teas are apparently affected by the coloured degradation products of chlorophyll to pheophytin and pheophorbide and by the reddish-brown thearubigins (TR). The coloured degradation products of chlorophyll were separated in an extract of the made tea by TLC on silica gel plates. It was observed that the extent of chlorophyll degradation is more in orthodox than in C.T.C. manufactures (Table 8.10).

Table 8.10. *Extent of degradation of chlorophyll in Orthodox and C.T.C. teas*

Degradation products	Orthodox tea	C.T.C. tea
Chlorophyll a	—	++
Chlorophyll b	++	+++
Pheophytin a	+++	+++
Pheophytin b	++	++
Pheophorbides	++	+

Residual chlorophyll a in orthodox teas is nil or only trace whereas a good amount of both chlorophyll a and b is left undergraded in C.T.C. process. Further the quantity of pheophorbides is more in orthodox than in C.T.C. teas. All these show that chlorophyll degradation is more in orthodox than in C.T.C. process. At the same time, the amount of reddish-brown TR formed in orthodox process is much less than that in C.T.C. It therefore appears that chlorophyll degradation products dominate in orthodox teas. Reverse is the case in C.T.C. teas where the amount of TR is much higher to impart a brown shade to C.T.C. teas.

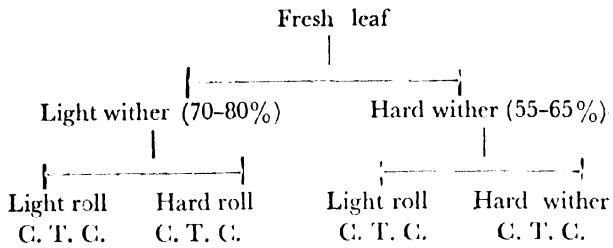
The degradation of chlorophyll is initiated right from the withering of the leaf (Ann. Rept. 1978–79) and continues through fermentation till the end of drying of the fermented leaf. In order to see the effect of drying on the chlorophyll content, a part of the fermented leaf was vacuum dried eliminating the heat effect. Comparative TLC on silica plate of the extracts of vacuum dried and the black teas showed greater amount of chlorophyll degradation in the usual dried teas. Specially, the conversion to pheophorbides was more on application of heat.

Fermenting leaf (Orthodox/CTC) dried at different periods of fermentation showed the same extent of chlorophyll degradation on TLC. This is probably due to the heat effect on the degradation of the chlorophyll. It was however observed that with extended time of fermentation, the brown shade of tea increases as the TR content goes up.

In order to monitor the extent of chlorophyll degradation during fermentation, vacuum dried fermented leaf samples may have to be examined.

MANUFACTURE OF BLACK SHADED TEA

It was observed that by slowing down the fermentation rate in C.T.C. manufactures, comparatively blackish teas could be made from clones prone to produce brown C.T.C. teas (Ann. Rept. 1981–82). Attempts were made to change the processing conditions in order to slow down the rate of fermentation to produce blackish teas. In an experiment, tea leaves from TV 1 and TV 16 were subjected to the following treatments :



Results of this trial are presented in Table 8.11.

Hard wither of the leaf slowed down the rate of fermentation and TV 16 produced blackish tea. TV 1 being a faster fermenting clone, the production of TR could not be checked with the usual fermentation time and the teas appeared brownish. Further trials are necessary to slow down the fermentation.

STUDIES ON THE CHEMISTRY OF TEA

Lipids

Lipids which occur to the extent of 9 percent of the dry weight of fresh leaf are important precursors of black tea aroma and undergo considerable changes during black tea processing due to the action of lipid degrading enzymes and other oxidising agents. The variations in the amount during different stages of processing is presented in Fig. 8.04. Lipid content depends on the type of the leaf, agropractices and the chloroplast maturity. While the degradation starts at withering, a major portion is also lost during fermentation stage and the drying appears to be less significant. 20 percent loss during withering was observed whereas the total

Table 8.11. *Effect of variation in withering and rolling on TF, TR contents, valuations and shade of C.T.C. teas from TV 1 and TV 16*

Source	Processing conditions	% TF	% TR	TF/TR	Tasters valuation Rs/kg			Shade
					A	B	C	
TV 16	LW/LR (control)	1.39	16.30	0.09	8.40	7.20	17.60	Brownish
(4 replications avg)	LW/HR	1.39	16.34	0.09	8.20	7.20	17.60	Brownish
	HW/HR	1.25	15.41	0.08	8.80	7.40	17.40	Blackish
	HW/LR	1.18	15.45	0.08	8.60	7.20	17.40	Slight Brownish
TV 1	LW/LR	1.53	16.36	0.09	8.17	6.67	17.63	Brownish
(4 replications avg)	LW/HR	1.46	16.53	0.09	8.83	7.00	17.50	Brownish
	HW/HR	1.27	16.10	0.08	8.33	7.67	17.50	Brownish
	HW/LR	1.27	16.08	0.08	8.50	7.33	18.83	Brownish

LW/LR, Light wither/light roll
LW/HR, Light wither/hard roll
HW/HR, Hard wither/hard roll
HW/LR, Hard wither/light roll

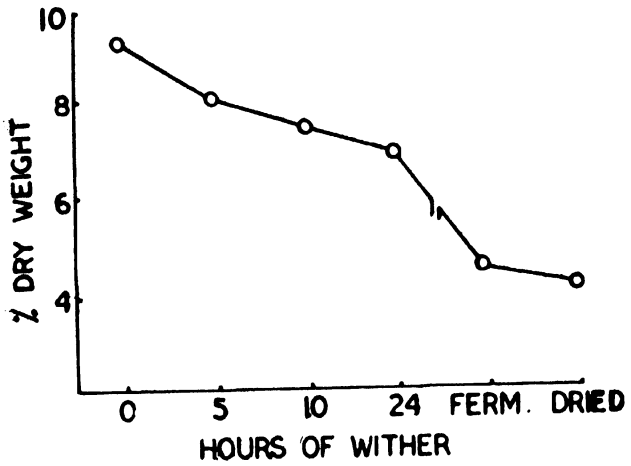
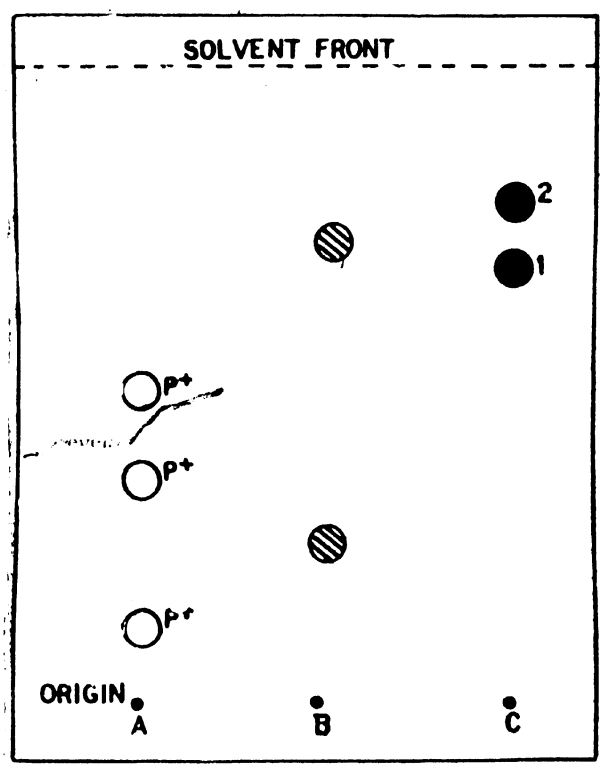


Fig 8.04. Variation of total Lipid content during processing of Bulk Tea



P+ : PHOSPHATE POSITIVE LIPIDS
: SAPONINS
SPOT 1 : LINOLENIC ACID
SPOT 2 : LINOLEIC ACID
DEVELOPING SOLVENT FOR A AND B – CHLOROFORM : METHANOL (90:10)
DEVELOPING SOLVENT FOR C – CHLOROFORM : METHANOL : ACETIC ACID : WATER (170:30:20:4)

Fig 8.05. TLC Pattern of some Lipids of Polar lipid fraction from tea.

degradation was found to be around 50% of the fresh leaf at the end of drying. Linolenic, Linoleic and Palmitic are three major fatty acids released during black tea processing which is attributable to lysis of neutral, glyco and polar lipids. These acids undergo further degradation to form flavoury components.

Fig. 8.05 shows the different components of the polar lipids seen in thin layer chromatogram (silica gel) developed with chloroform-methanol-acetic acid-water (170:30:20:4).

Compositional changes of Carotenoids

The quantitative changes of the four major carotenoids viz. β-carotene, lutein, violaxanthine and neoxanthine were followed during four flushes in TV 1, TV 9 and TV 17. The marked changes of these pigments (Fig. 8.06 to 8.09) are observed throughout the plucking period starting from April to October during 1982. Highest amount of carotenoid in the month of April is attributable to extraplastidic reaction pathways as expected from cold dry, windy nights in the preceding months. Lowest amount is seen either in the month of June or July.

Carotenoid in the fresh leaf is considerably small in amount compared to polyphenols and is expected to contribute significantly to the flavour profiles. Clonal variation of carotenoids is usually observed and is represented in Fig. 8.10. TV-17 with marked China character is relatively, as compared to Assam type clone TV-2, rich in these four major carotenoids. Flavour profile of TV-17 was also found to be rich in terpene

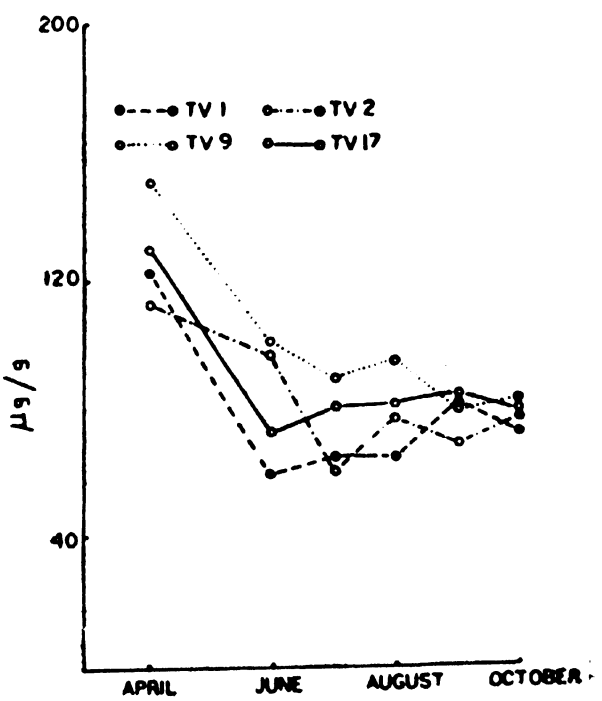


Fig. 8.06. Seasonal Variation of β-Carotene

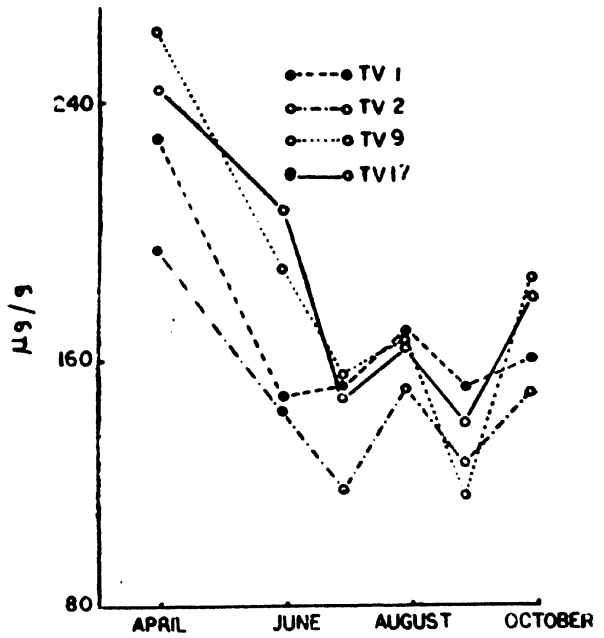


Fig 8.07. Seasonal variation of Lutein.

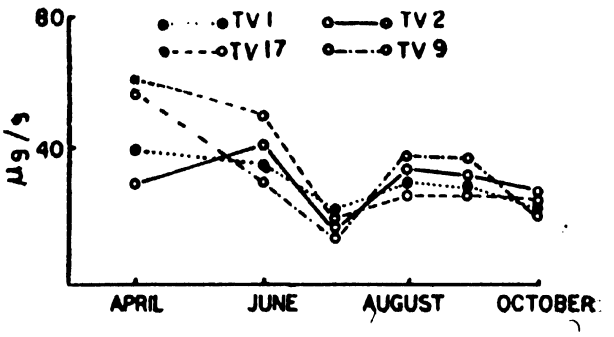


Fig. 8.08. Seasonal variation of Violaxanthin.

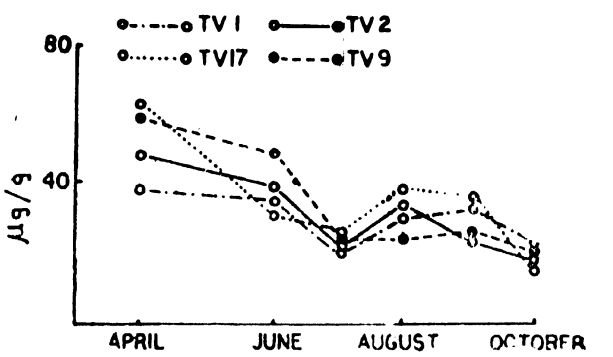


Fig 8.09. Seasonal variation of Neoxanthin.

alcohols, ionones which are reported to be the degradation products of carotenoids.

Significantly higher degradation of carotenoids is observed in CTC teas as compared to orthodox teas which is attributable to greater exposure of the polyphenols caused by severe cell damage in the CTC machine. Orthodox teas with lesser carotenoid degradation is in fact more flavoury due to greater retainment of essential flavoury components along with carotenoids. Moreover higher amount of oxidised polyphenols in

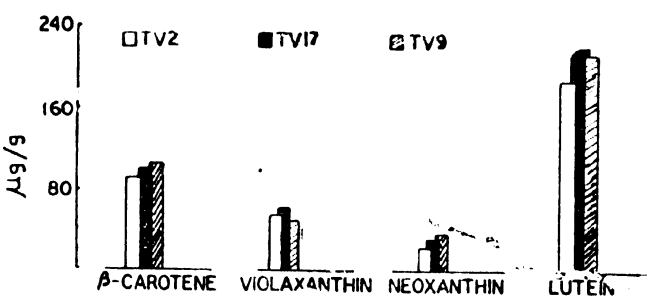


Fig 8.10. Relative Concentration of different Carotenoids in various clones.

Table 8.12. *Degradation of carotenoids in Orthodox and C.T.C. teas.*

	Clone Samples	β Carotene		Lutein		Violaxanthine		Neoxanthine	
		µg/gram dried weight	Percent of Original	µg/gram dried weight	Percent of Original	µg/gram dry weight	Percent of Original	µg/gram dry weight	Percent of Original
TV 1	Fresh leaf	97.36	100.00	163.15	100.00	42.50	100.00	44.73	100.00
	Orthodox	75.00	77.03	88.50	55.24	19.50	45.88	33.00	76.78
	C.T.C.	61.50	65.17	73.50	45.05	15.00	35.29	61.48	61.48
TV 2	Fresh leaf	103.44	100.00	166.36	100.00	38.18	100.00	35.75	100.00
	Orthodox	85.00	82.17	142.50	85.66	19.50	51.07	27.30	76.36
	C.T.C.	72.00	69.61	130.50	78.44	13.50	39.29	23.50	65.73
TV 17	Fresh leaf	103.15	100.00	202.70	100.00	64.86	100.00	62.16	100.00
	Orthodox	73.50	62.63	153.00	75.43	31.50	48.57	31.50	50.68
	C.T.C.	66.00	48.84	99.00	48.84	21.00	33.70	25.50	41.02

CTC leaves might influence the formation of low boiling secondary oxidation products of carotenoids such as hydrocarbons and aldehydic compounds.

Water soluble pigments

Water soluble pigments in black tea such as TF and TRs vary with tea shoots with different genetic and morphological character. Variations of these pigments are attributable to the nature of processing such as orthodox roll, roll and CTC and rotorvane CTC. TF and TR amount in different parts of the tea shoots are presented in table 8.13, which is attributable to

the variations in the chemical characteristics of the shoot constituents.

Table 8.14 shows the amount of major TR components in CTC teas manufactured from TV 1, TV 2, TV 9 and TV 17. These pigments as separated on the sephadex LH 20 column using 60% aqueous acetone as eluent, were estimated from extinction values presented in table 8.14.

Table 8.13. *TF & TR contents in teas manufactured from different parts of the shoots of TV 8 with taster's assessment.*

Parts of the shoot	TF	TR	TF/TR	Taster's assessment
Bud	1.55	12.99	0.12	Very good
1st leaf	1.48	17.16	0.09	Good
2nd leaf	1.23	18.50	0.07	Fair
3rd leaf	1.10	17.86	0.06	Poor
Stem	1.15	12.53	0.07	Fair

Table 8.14. *Amounts of the major Thearubigin fractions in clonal teas with their absorbance values.*

Component of TR	$A_1^{1\%}$ cm at 460 nm.	Percentage of dry wt.
TR-1	8.73	2-6
TR-2	8.73	1-3
TR-3 (total)	14.30	13-18
TR-3 (Ethyl acetate soluble)	28.40*	1-2

* Value available in the literature

From the variation in the TR components and TF as seen in pigment profile obtained by monitoring at 460 nm., it is possible to ascertain the fermentation behaviour of the clonal teas. TV 2 with slow fermenting property has the tendency to form high TFs and low TRs, whereas the fast fermenting clone TV 1 produces high amount of TRs, especially TR 1, and low amount of TF. TV 17 with considerable fermentation ability is rich in both TF and TRs to prefer as self drinking clone. Very high substrate concentration is another factor for richness in all these TF and TR pigments. Unlike the fast fermenting clone TV 1, the TR 1 content does not reach unusually high value due to the small increase in the fermentation time. TV 9 shows to be medium fermenting clone with considerable amount of all these pigments.

The extinction values of TRs (Table 8.14) is important in determining colour and strength of black tea.

Tea cream which is also one of the important quality factors, is analysed for these pigments. Pigment profile analysis of tea cream shows (Fig. 8.11) that TR 1 and ethyl acetate soluble portion of TR 3 are major components whereas in the decream portion TF and TR 3 are the major components.

Unwithered CTC teas contain low amount of TR 1 and high amount of TF. Moreover the creaming ability of these teas are much less compared to withered CTC teas. Diminishing cream may be assigned for

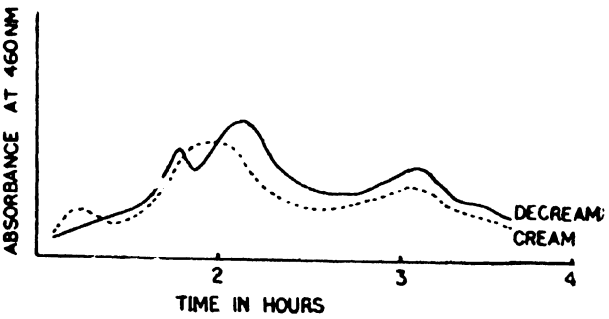


Fig 8.11. Pigment pattern of Cream and Decreamed liquor

low TR-1 content. Thus it is apparent that from these studies that TR 1, TR 2 and TR 3 play a very significant role in ascertaining the quality of liquor made tea.

From the analysis of these pigments, it is clear that careful leaf handling is a precondition for fast fermenting leaves to have desired cup character. Aeration and humidity are another two factors to be looked into during fermentation.

Volatile flavour components (VFC)

Although the black tea aroma is reported to be constituted of about 300 volatile components, the essential characteristic aroma is expected to be controlled by about 20 important volatile components. The aroma profile is mostly formed through degradation of lipids, unsaturated fatty acids, carotenoids and chlorophylls during processing. The factors affecting the peak pattern and hence quality are manufacturing and agro-climatic conditions along with the genetic characters of the leaves. It is the latter aspect which is responsible for different flavour profile in various clonal teas.

The fig. 8.12 shows the VFC pattern of unwithered and withered CTC teas. Trans-2-hexenal, linalool oxide (5 trans), geraniol, benzaldehyde and 2-phenyl ethanol show significant variations in their amounts in both these teas. Characteristic components with flowery note seem to be higher in withered CTC teas indicating that withering is an essential pre-condition for their formation.

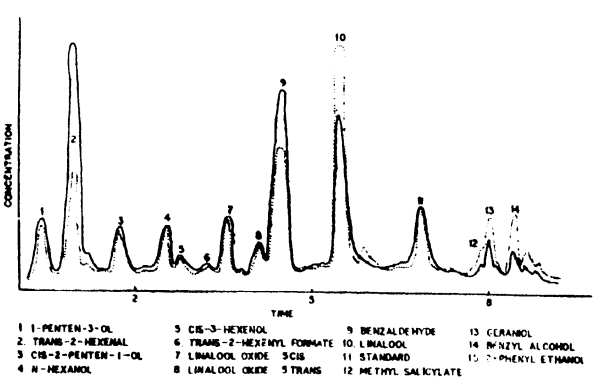


Fig 8.12, VFC Pattern in Withered(...) and unwithered(—) CTC Teas

Studies on polyphenol oxidase and peroxidase

A simple procedure for the solubilisation of tea oxidase from tea shoot acetone powders has been standardised. The enzyme is eluted from the acetone powder with salt solution with good recovery of the activities. The eluted enzyme was further purified on DEAE-ion exchange cellulose. The active fraction was almost free of peroxidase. Peroxidases could be fractionated into 2-3 isozymes.

Using this simplified procedure the oxidase-peroxidase pattern of various components viz Bud, First leaf, Stem, 2nd leaf and mature leaf was studied. Preliminary results show that the shoots components show characteristic association of oxidase-peroxidase system. Work is in progress to follow the distribution of these two enzyme in the various components of shoots in greater detail. Oxidase-peroxidase pattern of different clones and also their variation during the manufacture season will be attempted. Detailed studies on the enzymes will help in determining the role of these two in the generation of tea pigments during fermentation.

Preliminary indications again have shown that a combination of oxidase with different types of peroxidase is likely to impart different substrate specificity. Studies will be continued.

Evaluation of tea quality by chemical test

In an attempt to correlate chemical test with taster's valuation about 489 commercial tea samples of eight different grades from 29 different tea estates obtained through M/S Eastern Tea Brokers were examined during June to November. A positive correlation between chemical test and taster's valuations has been indicated in five major grades of CTC teas (Table 8.15).

From the table it is seen that the chemical test has a great potential in assessing the liquor character. The experiment will be re-designed and will be continued.

Table 8.15. *Correlation of chemical test with Tasters' valuations in some auctioned teas.*

CTC Grades	Correlation coefficient between Tasters valuations and chemical test.
BOP	0.5817 ***
BOP(S)	0.3369 NS
BOP(L)	0.3778 NS
BP	0.4405 ***
BPS	0.5132 ***
PF	0.4268 *
OF	0.4296 ***
All grades combined	0.4172 ***

*** Significant at P = .001
* Significant at P = .05
NS No significant correlation

Miscellaneous

A simple and rapid method for determination of polyphenols in tea shoots and at various stages of tea manufacture has been developed. The method will be reported elsewhere after a few more tests.

Advisory services

Kay-bee and N-foss Moisture meters (15) of various member estates were serviced and calibrated. Detergent samples (4) received from Tea Taster were examined for their suitability for use in the tea factories.

The teas sent by a few gardens were analysed for their TF and TR content.

General

The Biochemist attended 6 Area Scientific Committee meetings and also a discussion on ISO specification. Dr. M.R. Ullah attended 2 ASC meetings and Dr. P.K. Mahanta attended one ASC meeting.

Dr. P. K. Mahanta has been recognised as a Ph.D research guide from Gauhati and Dibrugarh University.

Tea Tasting

Highlights

Kraft paper board carton named 'Rubsteel', a new alternative tea chest to plywood tea chest has been tested for packing of tea and found suitable but considered uneconomic.

Leaf appearance and cup quality of C.T.C. tea improved by adopting new modes of adjustment in C.T.C. machines.

C.T.C. manufacture of Darjeeling rains tea produced better strength and flavour.

Quality of Dooars tea improved by mixing of clonal tea with seed jat tea in a desired proportion.

'Teagard', a new alternative lining material for tea chests for packing of tea appeared to be promising and is under rigorous investigation.

Alternative tea chests

In continuation of the previous work on storage of tea in Kraft paper board carton named 'Rubsteel' box (Ann. Rep. 1981-82, p66), as an alternative to plywood tea chest, further tests were conducted to find out the effect of storage on tea stored in this 'Rubsteel' box for one year.

Data on moisture, TF and TR contents of teas packed in plywood tea chests, as control, and experimental 'Rubsteel' boxes after storage for a period of one month upto one year are presented in Table 9.01 below.

Table 9.01. *Data on moisture, TF and TR contents of tea in conventional plywood tea chests and experimental 'Rubsteel' carton boxes stored for a period from one month to one year.*

Period of storage	Initial moisture content %	Moisture Content in %		TF Plywood chests	TF Rubsteel boxes	TR Plywood chests	TR Rubsteel boxes
		Plywood chests	Rubsteel cartons				
1 month	2.5	4.79	4.27	.98	.88	17.79	17.29
3 months	—	5.41	1.96	1.21	1.24	14.66	15.02
6 months	—	6.24	6.03	1.02	.99	16.57	15.51
9 months	—	6.65	6.40	1.82	1.13	15.52	14.97
12 months	—	8.44	8.14	1.33	1.34	15.13	14.85

The data from the above table do not reflect any significant difference in moisture content of the teas packed in Rubsteel carton boxes and the conventional plywood tea chests during the period of one year storage. There is also no significant difference in the polyphenol constituents of the teas stored in the experimental boxes and conventional plywood tea chests throughout the year.

Neither any taint nor any adverse effect was detected on the liquors of the made teas packed and stored in the Rubsteel cartons for one year. Although after a continuous search this material was found suitable for an alternate to plywood for tea chest material it was considered uneconomic from the point of view of its comparative higher cost than plywood tea chest.

Improvement of colour of C.T.C. teas

In tune with the consumer's taste it has been urgently felt that besides leaf appearance some ways and means need to be found out to improve the quality of C.T.C. liquor by the manufacturing process. With a view to achieve this the department initiated to find out some means suited to regional conditions as in Dooars, Cachar and Tripura.

A method has been devised in C.T.C. manufacture to maintain leaf appearance and cup quality in desirable standard. The method has been tried out under commercial factory conditions in Dooars and Cachar and a few trials were also conducted under Assam conditions.

For this method it was aimed to wither down green leaf to about 72—74% moisture in Dooars and 75 to 80% in Cachar. The withered leaf was pre-conditioned by Rotorvane. After pre-conditioning the processed leaf was fed thinly to first C.T.C. cut. The adjustment of the first and second C.T.C. cuts given was hard instead of progressive hard cut in 8 TPI roller. The third cut given was a little lighter in 10 TPI roller with a marginal clearance in between the rollers. The 8 TPI roller was of 50 helical grooves and 10 TPI 60 helical grooves with 'U' profile grooves. After the third cut C.T.C. the mal was passed through a googie sifter. The comparative percentage of different grades were worked out in different factories and revealed an average of 10 to 12% increase in smaller grades and reduced the percentage of larger balls. While using 10 TPI roller in the second and third C.T.C. cuts, Fannings and Dust grades percentages increased to about 5 to 6%.

While the above method was tried in Roll/C.T.C. in 8 TPI 40 helical grooves using the angle of chasing grooves at 45° in first C.T.C. cut there was slight re-

duction of broken grades percentage which may be due to Roll/C.T.C. manufacture. However the percentage of rough grades was more compared to normal progressive cut method. The observation showed some improvement on the appearance of the tea.

C.T.C. manufacture in Darjeeling in Rains

As reported last year, C.T.C. method of manufacture in Darjeeling in rains flush was followed up again this year also. But due to technical constraints the trial of the process could not be carried at Clonal Proving Station, Ging. The leaf from Ging was brought to Nagrakata and manufactured at the Nagrakata Miniature Factory on the next day.

The result of the trial showed that by adopting C.T.C. method of manufacture during the rains, teas with better strength and flavour could be produced from Darjeeling leaf. The TF and TR contents of these teas are also found quite satisfactory in comparison to plains teas and these findings were corroborated by the Tea Tasters in their reports as well.

It is proposed to continue this experiment in a commercial garden at Darjeeling in the next season.

Blending of clones

In continuation to last year's trial on the effect of mixing of clonal tea with seed jat tea in different proportions further trials were carried out under a different agro-climatic condition in Dooars.

The experiment was designed to mix each of clonal leaf with Betjan jat leaf separately. The clones were TV1, TV9 and TV18. On each occasion the mixed leaf was withered down to 75%. When 20% of TV1 was mixed with 85% Betjan jat leaf, the cup character and quality of the tea improved. Similarly on separate occasions when 25% each of TV9 and TV18 was mixed with 75% Betjan jat there was again overall gain in the liquor character and quality considerably.

The trial is proposed to be continued in the next manufacturing season.

New alternative lining materials for tea chests

To meet the industries' need for alternative lining materials for plywood tea chests, another new lining of 0.009 mm aluminium foil/30 gsm paper laminated under the brand name 'Teagard' was tested along with standard conventional lining in 50 kg plywood tea chests.

The interim findings, based on storage of tea for six months, showed that it did not impart any taint or caused any adverse effect on the liquor of the made teas. Moreover, there was hardly any difference between the experimental and standard linings in respect of Tasters' evaluation and biochemical assessment of TF and TR contents and moisture gain during the period of storage under the conditions of the trial. Teas stored in this lining material maintained the same characteristics as tea stored in plywood chests having aluminium foil and tissue paper lining.

Tea Grading Nomenclature

During the year an experiment on Tea Grading Nomenclature was carried out at Tocklai for standardisation of all grades of orthodox and C.T.C. teas in N.E. India purchased all over the country.

It has been looked into the details of all grades of orthodox and C.T.C. teas for bulk density and size. Both the types of the teas were passed through different sizes of wire meshes. The average percentage of tea particles that remained on top of the particular wire mesh sieve and the remaining percentage below sieves were weighed by precision balance. All the grades of made teas of each wire mesh were sorted by hand sieves being strictly aware of giving equal and identical treatment in respect of time and movement of sieves in each operation.

The experiment has only been initiated to be carried out further for more information on standardisation.

Tea Breaker cum stalk separator machine

During the year the department was entrusted by the T.R.A. Engineering Sub-Committee to initiate a trial of a new Tea Breaker cum stalk separator machine developed by the Engineering R & D Department at Tocklai in a tea factory for commercial trial.

This model machine was installed at Heeleakah T.E. in Assam for commercial trial under Assam conditions in order to compare with the standard Andrews Breaker.

During the preliminary trial it was observed that the main broken grades made by the estate contained crushed stalk and these were difficult to extract. But this difficulty was less with the new machine and the grades contained floated stalks only instead of crushed stalk.

The machine was not fully exploited during the year due to non-availability of sufficient leaf. The following tables give a brief idea of grade percentage contained and comparative valuations of bulk samples given for coarse mal passed through the two machines.

Table 9.02. *Comparative average grade percentages*

Grades	Grade % from Andrews Breaker	Grade % from New Breaker
Whole leaf grade	6.23	8.83
Broken grade	59.42	64.39
Fannings	5.35	6.25
Dust	5.87	5.36
Secondary	4.62	2.01
BT Tea waste residue	18.51	13.16

Table 9.03. *Comparative valuations of samples from 100% coarse mal passed through different machines*

Date	Taster's valuations Andrews Breaker Rs/kg	Taster's valuations New machine Rs/kg
30.10.82	9.50	10.50
2.11.82	10.00	12.50
5.11.82	10.00	10.50
9.11.82	9.50	9.50
12.11.82	10.00	10.00
18.11.82	9.50	10.50
24.11.82	10.00	11.00
7.12.82	10.00	11.00
14.12.82	10.00	11.00

Number of comparative set samples	—	10
Number of times new machine samples preferred	—	7
Number of times Andrews Breaker samples preferred	—	Nil
Number of times similar valuations given	—	2

From the above data it is clear that the New Machine is now in a position for breaking of orthodox tea suitably to desirable sizes.

During the trial run it was observed that the stalk which passed through the new machine and remained uncut could be separated by hand picking only with subsequent cleaning or breaking of dry leaf into desired sizes. The production of orthodox broken grades processed by Andrews Breaker was not so even as processed by the new machine. The percentage was quite high, roughly 65% after passing 100% coarse mal twice through the new machine. After cutting three times in Andrews Breaker the teas lost bloom completely having acquired greyish colour. The interesting feature of the new machine is the smooth action on the leaf with consequent preservation of tip and bloom.

The present output of the machine is considered rather low and needs further improvement. Therefore after necessary modification the trial of the machine will be continued in the next manufacturing season for its commercialisation.

Meetings and Seminars

Six seminars on Engineering and Manufacturing held by different Area Scientific Committees, the joint Area Scientific Committee meeting held in Cachar, one seminar of NABARD at Tocklai, one demonstration of Fluid Bed Drier at Harishpur T.E., a joint meeting of the Engineering Sub-Committee, T.R.A. and I.T.A. Technical Sub-Committee were attended by the Tea Tasters.

Advisory Work

40 group tasting sessions were arranged by the Area Scientific Committees in different parts of N.E. India. The tasting sessions were followed by discussions on tea manufacture under different factory conditions. The Tea Tasters visited 120 tea factories.

Tasting

Tea samples tasted during the year at Tocklai numbered 35,902 including samples from Nagrakata Sub-Station and Darjeeling

Engineering Research & Development

Highlights

Trials of the modified 45 cm B.C.R. for the first roll have been completed and its drawings prepared and passed over to manufacturers for commercialisation.

Necessary modifications for adoption of the 37cm B.C.R. in South India have been worked out.

Developmental work on the pilot model Continuous withering machine resulted in improvement of its capacity to more than double. Work on improving its performance further is in progress.

A tea breaker which discriminately breaks tea only leaving out stalks intact, designed and developed earlier has been tried out with very encouraging results.

A preliminary study on the efficiency of magnets presently used in tea factories for separation of iron particles has been made.

The Japanese plucking aid machines along with plucking shears have been tried out further and their performance studied.

In the collaborative projects taken up with C.M.E.R.I. all the C.T.C. segments have been tried out. Design drawings for a new arrangement of mounting C.T.C. rollers for their easy replacement have been sent by C.M.E.R.I.

Boruah Continuous Roller (BCR)

First roll trials of the B.C.R. were continued during the year at Hunwal T.E. While for the first pass the modified 45 cm. prototype was used, for the second pass a 45 cm commercial B.C.R. manufactured and supplied by M/s Steelsworth Ltd. was used. The commercial 45 cm B.C.R. which is normally used for the second roll was found to be unable to show the same good performance and capacity when used as a second pass machine and was fed with half rolled leaf. Some modifications to the vanes on the rotor increased its capacity to take in 1700 kg/hr half rolled leaf from the 1st pass machine. But it needed further modification to get fully satisfactory results in the second pass of the first roll. Hence a new rotor similar to the one in the first pass machine, fabricated and supplied by M/s Steelsworth Ltd. on request was fitted towards the beginning of September and the trials were continued.

Tasters' valuations of the comparative first fine samples from B.C.R. and conventional roller are given in Table 10.1. From the tasters' valuations it is seen that there was a definite trend of improvement in the valuations of B.C.R. first fine samples after September.

Table 10.1. *Trial of Boruah Continuous Roller for 1st Roll. Monthwise average comparative valuations of first fine samples in Rs/kg as given by Tocklai Tasters*

Month	Taster A		Taster B	
	B.C.R.	Conventional	B.C.R.	Conventional
April/May	9.31	9.46	8.77	9.07
June	9.18	9.18	9.46	9.78
July	9.38	9.58	8.83	9.21
August	9.56	9.33	8.56	8.33
September	9.40	9.55	8.10	8.30
October	9.75	9.50	8.50	8.75
November	9.57	9.43	8.86	9.00

Towards the end of the season two roll 100% orthodox manufacture was tried out for three days using the 40 cm prototype B.C.R. for the second roll. On sorting it was found that B.C.R. gave a higher percentage of leaf grades and nearly equal percentage of brokens with a lower percentage of residue. The details of grade percentages are given in Table 10.2.

Valuations of comparative samples of various grades given by Tocklai Tasters along with overall weighted average valuations are given in table 10.3. In calculating the weighted average valuations the residues are not included. As the residues are less in the case of B.C.R. their inclusion will help B.C.R. samples to compare more favourably with conventional samples. Now it is felt that as orthodox rolling system with B.C.R. is a new concept it should not be equated with conventional system in all respects and the machine should be released for commercial production. Hence the necessary drawings of the 45 cm B.C.R. for first roll have been prepared and sent to the manufacturers, M/s Steelsworth Ltd. and M/s Trade & Industry Pvt. Ltd for commercialisation.

M/s Steelsworth Ltd. have already undertaken the manufacture of two commercial model Boruah Continuous Rollers for first roll, one for the first pass and the other for the second pass for trials at Duamara T.E.

Table 10.2. *Trial of B.C.R. in 2-roll 100% orthodox manufacture. Comparative grade percentages*

Date	B.C.R.					Conventional				
	% TGFOP	% GFOP	% GFBOP	% FBOP	% Residue	% TGFOP	% GFOP	% GFBOP	% FBOP	% Residue
10.11.82	9.26	9.89	35.76	35.28	9.81	4.15	9.06	35.24	35.44	16.11
11.11.82	9.60	9.41	36.04	35.24	9.71	3.35	9.19	36.76	34.13	16.57
12.11.82	10.15	9.56	35.30	35.82	9.17	3.85	8.86	34.36	37.21	15.72

Table 10.3. *Trial of B.C.R. in 2-Roll 100% orthodox manufacture. Comparative Valuations in Rs/kg as given by Tocklai Tasters*

Date	Grade	Taster A		Taster B	
		B.C.R.	Conv.	B.C.R.	Conv.
10.11.82	TGFOP	10.00	9.50	9.00	10.00
	GFOP	9.00	10.00	9.00	10.00
	GFBOP	9.50	10.00	9.00	9.00
	FBOP	9.00	10.00	8.00	9.00
11.11.82	TGFOP	9.00	10.00	10.00	11.00
	GFOP	9.00	10.00	9.00	10.00
	GFBOP	9.00	10.00	8.00	9.00
	FBOP	9.00	9.50	9.00	9.00
12.11.82	TGFOP	10.00	9.50	9.50	10.00
	GFOP	9.50	10.00	8.00	10.00
	GFBOP	10.00	9.00	10.00	9.00
	FBOP	10.00	9.00	9.00	8.00
Overall weighted average valuations		9.44	9.62	8.87	9.01

These machines are expected to be ready for trials early in the next season.

The 37 cm B.C.R., meant for 2nd or subsequent rolls, which was commercialised last year was tried out by both the manufacturers in South India. While the tea produced by the machine there was found to be satisfactory, the amount of second fines produced was found to be low as per South Indian Standards. Necessary modifications have been worked out for a more severe rolling to produce more amount of second fines and suggested to the manufacturers for trial.

Development of Withering Equipment

The pilot model continuous withering machine designed, developed and tried out with satisfactory results earlier has been modified for doubling its capacity. A mechanical leaf spreader was also designed and developed and was fitted to the Continuous withering machine. The machine complete with the mechanical spreader was tried out towards the end of the season. The capacity of the machine, as stipulated, was found to be 60 to 70 kg/hr. i.e. double the earlier capacity and the mechanical spreader worked very satisfactorily. But with increased amount of leaf the resistance to the hot air blast was more and, hence, the designed degree of wither could not be achieved. Instead of using extra power to overcome this resistance to air flow now attempts are being made to change the air flow pattern to achieve the desired degree of wither. The work on the necessary modifications has been taken up.

Cleaning of Made Teas

In an attempt to separate out stalks from orthodox tea by discriminate breaking of tea alone leaving out stalks intact, a model was prepared. The idea was to break coarse bulk tea discriminately and then to separate out the unbroken stalks by a Mydelton stalk extractor. Some preliminary trials conducted with the model showed that although the resulting grades are not completely free from stalks, they are much cleaner and have remarkably better bloom than the normal grades. In fact it was found that the bloom was not at all lost even after repeated breakings for several times to extract the last bit of tea left in the coarse bulk. Thus, by the use of this principle secondary grades can be completely avoided and at the same time cleaner grades containing only a few floating stalks may be obtained. The model was installed at Heeleakah T.E. towards the end of the season and was tried out by the Tea Tasting Department. The results of this trial as reported by the Tea Tasting Department not only confirm the above findings but also show that this model tea breaker gives higher percentage of useful grades which are valued appreciably higher than the grades similarly obtained by using Andrew's Breaker.

Iron Contamination in Tea

Samples of various grades of tea were collected at the point of packing from three different factories using permanent magnets on the C.T.C. conveyors and at different points after drying. Results of the analysis of these samples for iron contamination by the Biochemistry department is given in Table No. 4. From the results of the analysis it can be seen that even after using

Table 10.4.

	Sample	Iron in ppm.
Garden A	PD	100
	Dust	100
	OF	Nil
	BOP	Nil
	BOPS	Nil
Garden B	Dust	400
	CHU	600
	OF	100
	BOP	Nil
	BP	Nil
Garden C	PD	200
	Dust	600
	BP	Nil
	BPS	200

magnets the iron contamination in dust grades can be as high as 600 p.p.m. Among the three gardens garden C is using magnets at maximum number of points, but its results are not better than other gardens. Hence to find the possibility of better removal of iron particles it is now proposed to conduct an experiment with an elaborate system of suitable types of permanent magnets installed at all suitable points. Negotiations have been made with Balijan North T.E. for this purpose. This garden has been selected because its factory has a suitable layout for installing magnets, some of which already exist there. Trials would be possible only after the magnets have been acquired and installed. In the meantime, some more trials will be taken with the existing magnets at a lower conveyor speed and thinner spread.

Studies on Mechanical Plucking Aid

Two pairs of plucking shears have been received towards the end of June. Trials of these shears along with the two Japanese plucking aids, one battery operated and the other 2-stroke engine operated, were started from early July and continued through the season for comparing the performance of the shears with manual plucking and also with the Japanese aids. The results of the trials are given in table 10.5.

Table 10.5. *Trial of plucking shears and Japanese Plucking Aids Monthwise average value of rate of plucking, percentage of fines and percentage of damage*

Month	Particulars taken	Av. rate of plucking in kg/hr.				Av. % of fine leaf plucked				Av. % of leaf damaged			
		Engine operated	Battery operated	Shears	Manual	Engine operated	Battery operated	Shears	Manual	Engine operated	Battery operated	Shears	Manual
July	Pruned	8.26	5.41	6.65	5.47	35.50	34.20	22.20	45.20	38.00	42.20	42.20	9.70
	Unpruned	8.30	7.05	7.88	5.80	28.50	30.00	28.80	58.70	45.7	56.00	44.20	11.00
August	Pruned	8.18	7.42	7.90	5.00	36.70	38.00	25.50	48.00	44.50	47.50	45.20	9.70
	Unpruned	9.15	9.10	6.69	4.59	32.25	39.00	24.75	59.50	55.00	58.00	54.20	11.00
September	Pruned	11.12	8.68	9.00	4.82	40.00	39.75	29.25	50.17	42.00	47.20	40.00	11.00
	Unpruned	8.75	8.59	7.87	4.01	33.50	36.50	27.00	54.00	52.00	50.20	45.75	13.00
October	Pruned	10.45	7.72	7.24	4.79	39.60	35.60	39.40	55.60	40.80	40.60	38.20	13.00
	Unpruned	12.45	8.30	6.92	3.62	40.80	45.20	36.6	60.6	39	38	36.80	10.18

The table shows that

(i) Speed of plucking with shears is between 1.2 to 1.9 times the speed of manual plucking while the Japanese machines is upto 3 times faster than manual plucking.

(ii) With shears the percentage of fine leaf by weight in the plucked leaf is around 30-35 whereas with Japanese aids it is 40-45.

(iii) With shears the percentage of damaged leaf by weight in the plucked leaf is around 40-55 which is nearly same as for the Japanese shears.

Collaboration with C.M.E.R.I.

(i) **Replacement of C.T.C. Segment Material**

Both quality test and wear and tear test of all the experimental C.T.C. segments supplied by C.M.E.R.I. have been completed during the year. For quality test leaves from the bulk were manufactured in the same manner by using experimental segments and standard stainless steel segments machined to same specifications and the samples were evaluated comparatively. Average valuations have been obtained from 8 repeats. In the wear and tear test the experimental segments were used to manufacture C.T.C. teas from around 60% fine leaf, withered 75% with a medium pressure. The results obtained are given in table 10.6.

From the table it can be seen that there is very little difference in the valuations between experimental and standard samples. Also, there was no adverse comment on the experimental samples. But in the case of nickel-coated cast iron segments the average valuation of the experimental samples, as given by either of the Tasters, was lower than the average valuation of the standard samples. The teas processed with these segments used to turn somewhat black during fermentation. It was also observed that the nickel coated cast iron and cast steel segments did not have the same sharpness after they were coated, and the teas processed with these segments were not well made from the beginning. In the case of bronze segments, particularly aluminium bronze, the teeth used to chip off during use and their damage caused by any extrancous metal piece was of greater extent than in the case of stainless steel segments.

Table 10.6. *Trial of experimental C.T.C. Segments Hours of service after a sharpening and Average comparative valuations in Rs/kg given by Tocklai Tasters*

Material of Experimental Segment	Hours of service after one sharpening	Taster A		Taster B	
		Experimental Segment	Stainless steel Segment	Experimental Segment	Stainless steel Segment
Manganese Bronze	47	9.56	9.81	7.75	7.37
Aluminium Bronze	32	8.37	8.19	6.37	6.31
Phosphor Bronze	25	8.37	8.50	7.12	6.87
Nickel coated cast Iron	16	8.37	8.62	7.00	7.37
Nickel coated cast steel	17½	8.56	8.69	7.12	6.94

(ii) **Redesign of C.T.C. roller mounting system**

As a result of the work taken up on this project in C.M.E.R.I. design drawings of a new arrangement of C.T.C. roller mounting system for their easy replacement have been prepared and sent by that Institute. These drawings have been studied at Tocklai and it was found that the design as given is not workable

and needs improvement. C.M.E.R.I. has been requested accordingly and they have now agreed to study the matter.

(iii) **Improvement of orthodox Table Roller**

It has been reported by C.M.E.R.I. that the necessary instrument for the study of the problem has been now received and work on the project is expected to start soon.

Meetings and Seminars

Six seminars on Engineering and Manufacturing held by different Area Scientific Committees, the Joint Area Scientific Committee meeting held in Cachar, a seminar organised by NABARD, one demonstration of fluid bed drier, two meetings of the Engineering Sub-committee and a joint meeting of the Engineering Sub-committee and I.T.A. Technical Sub-committee were attended by the Head, Engineering R & D.

Visits

The Head Engineering R & D visited Calcutta and C.M.E.R.I. once and M/s Steelsworth Ltd., Tinsukia twice. He visited 20 factories during the year.

Highlights

The study on crop and rainfall data for Bishnauth (North Bank) and Nowgong (South Bank) circles, Assam revealed that if rainfall deficiencies are replenished by irrigation during October to April in both the circles and adequate measures are adopted to drain out excess rain water during monsoon period, average annual yield is expected to increase by about 21 and 42 per cent over the actual average yield recorded in Bishnauth and Nowgong circles respectively.

Results so far obtained from the irrigation experiment at Tocklai Division from 1972 to 1982 are in line with the statistical findings for the Jorhat circle where one of the treatments was based on the statistical predictions.

Maximum quantity of rainfall, which can be expected in each month, to occur on an average, once in every 2, 5 and 10 years has been found out for 19 tea estates covering four circles of Assam Valley. This study is of great significance in deciding the magnitude of success of various field management practices, particularly of irrigation and drainage problems.

The study on analysis technique for long-term experimental data showed that if likelihood-ratio statistic method was followed to test the treatment effects, these were found to be significant, whereas F-test (usual method) did not show any significant difference. Though this is valid to establish the significance of the treatment effects, yet it is necessary to determine how the treatment effects vary with time. For this reason, some replicated time-series methods of analysis were tried and different models were generated to test the treatment effects precisely.

Analysis of NPK response surface data for 1981 which was the second year of the third pruning cycle of the 26 experiments on mature tea spread over 13 sites of North-East India, showed, in general, the same trend as in the previous years. The important point, however, is that requirement of phosphate is necessary every year at all the sites with N and K. However, the requirement of N, P and K varied from place to place. Even the new set of 13 experiments which were started from 1977 onwards showed similar results.

Results obtained from a survey conducted in 1981 through mailed questionnaire showed over-all vacancy under tea in North East India to be about 9.4 per cent. This has got great impact in lowering the productivity of tea. Regarding the use of clones in North East India, it was found that about 11 per cent of the total area under tea were planted with different clonal materials.

Crop-Weather Studies

A study on crop and rainfall relationship in the estates of Bishnauth and Nowgong circles in Assam were taken up with the objectives of this study outlined earlier (Annual Scientific Report, 1980-'81, p.66).

The data represented about 24 per cent of the tea growing area of the T.R.A. member estates in the Bishnauth circle for the period 1957 to 1976 and about 38 per cent in the Nowgong circle covering the period of 1957-'77.

Equations (1) and (2) show the critical periods of rainfall and their nature of relationship with the annual yield of tea in the estates of Bishnauth and Nowgong circles respectively.

$$Y = 9.8304\,R_1 + 19.2255\,\text{Log}_{10}(R_2 + 1.0) + 11.5470\,R_3 + 49.8333\,R_4 - 1.2833\,R_4^2 - 3.1330\,R_5 - 1.8774\,R_6 - 0.4895\,R_7 + 1008.6707 \quad \ldots\ldots(1)$$

$$Y = 78.3039\,R_1 - 2.1065\,R^2_2 + 30.5545\,\text{Log}_{10}(R_2 + 1.0) + 684.3781\,\text{Log}_{10}R^1_3 + 255.3203\,\text{Log}_{10}R_4 - 5.3434\,R_5 + 63.1980\,R_6 - 0.9599\,R^2_6 + 66.5522\,R_7 - 0.2993\,R_7^2 - 4373.2326 \quad \ldots\ldots(2)$$

where, Y = annual yield of made tea in kg/ha; R_1, R_2, R_3, R_4, R_5, R_6 and R_7 represent rainfall in centimetre during October, and November-December of the previous season, January-March, April, May, June and July-September of the current season respectively. Rainfall during these critical periods together accounted for about 84 per cent of the total variation in yield in the estates of Bishnauth circle, and about 78 per cent of that of Nowgong circle. Rainfall during October of the previous season and April of the current season contributed most amongst the critical periods in Bishnauth circle, as against October, January-March and July-September rainfall in Nowgong circle.

The distribution of rainfall during the critical periods and the type of their relationship with the annual yield in the Bishnauth and Nowgong circles are shown in Tables 11.01 and 11.02. These results suggest that there are deficiencies of rainfall in the estates of Bishnauth and Nowgong circles during October to April. There is also need to drain out excess rain water during May to September in both the circles. And by such measures, as replenishing the deficiencies during October to April and draining out excess rain water during May to September, the average yields are estimated to increase by about 21 per cent (301 kg of made tea/ha) and 42 per cent (573 kg of made tea/ha) over the actual yields recorded at Bishnauth and Nowgong circles respectively.

Results obtained so far from the irrigation experiments at Tocklai division from 1979-1982 are in line with the statistical findings for the Jorhat circle. Similarly, results obtained from the irrigation experiment conducted at Dam Dim T.E., Dooars from 1974—1980 are also in line with the statistical findings for the Dam Dim circle. In both the experiments some of the treat-

Table 11.01. *Rainfall distribution during different critical periods and irrigation requirement*
Region: Bishnauth Circle, North Bank, Assam

Critical Period	Rainfall (in cm)			Relationship*	Irrigation requirement (in cm.)		Average Yield (Made tea kg/ha)		
	Min.	Max.	Av.		Range	Av.	Without irrigation	With irrigation (estimated)	Gain due to irrigation (estimated)
October (Previous season)	2	29	14	Linear (+)	0 - 29	15			
November to December (" ")	0	8	3	Exponential (+)	0 - 8	5			
January to March (Current season)	4	17	11	Linear (+)	0 - 17	6			
April (" ")	4	28	15	Linear (+) Quadratic (-) TP = 19	0 - 19	4	1422	1723	301
May (" ")	25	60	39	Linear (-)	Drain out				
June (" ")	26	66	48	Linear (-)	Drain out				
July to September (" ")	89	161	120	Linear (-)	Drain out				
Total irrigation requirement				→	0 - 73	30			

* With (+) positive and (-) negative response and Turning Point (=TP).

Note for Table No. 11.01: Irrigation requirement during a critical period would depend on the quantity of rain received during the period. As for example, if rainfall received during October is 14 cm, then the irrigation requirement would be 29-14 = 15 cm. If it is 29 cm, then the requirement would be 29-29 = 0 cm, i.e., no irrigation would be required.

Table 11.02. *Rainfall distribution during different critical periods and irrigation requirement*
Region : Nowgong Circle, South Bank, Assam

Critical Period	Rainfall (in cm)			Relationship*	Irrigation requirement (in cm)		Average Yield (Made tea kg/ha)		
	Min.	Max.	Av.		Range	Av.	Without irrigation	With irrigation (estimated)	Gain due to irrigation (estimated)
October (Previous season)	3	21	11	Linear (+) Quadratic (-) TP = 19	0 - 19	8			
November to December (" ")	0	6	3	Exponential (+)	0 - 6	3			
January to March (Current season)	3	16	9	Exponential (+)	0 - 16	7			
April (" ")	3	38	16	Exponential (+)	0 - 38	22			
May (" ")	13	38	27	Linear (-)	Drain out		1380	1953	573
June (" ")	18	45	34	Linear (+) Quadratic (-) TP = 33	Drain out excess rain water				
July to September (" ")	85	125	107	Linear (+) Quadratic ( ) TP = 111	Drain out excess rain water				
Total irrigation requirement				→	0- 79	40			

* With (+) positive and (-) negative response and Turning Point (=TP).

Note for Table No. 11.02: Irrigation requirement during a critical period would depend on the quantity of rain received during the period. As for example, if rainfall received during October is 14 cm, then the irrigation requirement would be 29-14 =15 cm. If it is 29 cm, then the requirement would be 29-29 = 0 cm, i.e., no irrigation would be required.

ments were based on the statistical predictions obtained for the respective circle.

In the interpretation and implementation of the above results, however, it may be stressed that

(*i*) *Increase in yield due to irrigation would mainly depend on the rainfall received and quantity of water applied during each critical period and draining out the excess rain water during the critical monsoon periods (Tables 11.01 and 11.02).*

(*ii*) *The results relate to the average soil climatic conditions of the Bishnauth and Nowgong circles. Irrigation in an individual estate, however, should be based on a careful examination of such factors as distribution of rainfall, soil type, depth of soil of the concerned estate.*

(*iii*) *The results form the theoretical basis for a hypothesis on irrigation and drainage requirement by tea, which needs verification by a few more well-planned field experiments before large scale programme is adopted.*

Studies on Rainfall Probabilities

The investigation on rainfall probabilities was carried out for 19 tea estates of Mangaldoi, Borsola, Jorhat and Nowgong circles of Assam Valley to find

out the expected maximun quantum of total rainfall for each month, to occur on an average, once in every 2, 5 and 10 years at each of these estates. The study was based on 16 to 22 years monthly rainfall data collected through questionnaire from these estates.

The probabilities of occurring an event with 95%, 90% and 80% chances for different return periods, i. e., 2, 5 and 10 years for each month and for each of these tea estates have been established. The results for 5 year return period with 95% chances for the months of October to April only are presented in Tables 11.03, 11.04, 11.05 and 11.06 for these 4 circles of Assam Valley consisting of 19 tea estates. Detailed results will be presented elsewhere. It can be seen from these tables (11.03, 11.04, 11.05 and 11.06) that in order to ascertain the accuracy of the predicted maximum value, lower and upper limits for 95% confidence (probability) levels have been presented within which the actual value would lie.

It must be stressed that this study has great significance in deciding the magnitude and the degree of success of various field management practices in tea, particularly for irrigation and drainage problems.

Analysis Technique for Long-Term Experimental Data

This study is being carried out in collaboration with the I.S.I., Calcutta. Different methods have been tried out during the year to test the treatment effects precisely. One of the methods, i.e., likelihood-ratio statistic, shows that if this method is followed to test the treatment effects, these are found to be significant, whereas F-test does not show any significant difference. Though this is valid to establish the significance of the treatment effects, yet it is necessary to carry out the analysis further to determine how the treatment effects vary with time. The usual time series analysis involves one realisation of the process, there being a single observation at each time point, but in long-term experiments there are many observations at every point of time with the number of plots used in the experiment. For this reason, some replicated time-series method of analysis has been applied to the long-term experiments. Four models were generated for this purpose. This interesting study is continuing.

Collaborative Projects

(a) **NPK response surface**

Analysis of NPK response surface data for 1981 which was the second year of the third pruning cycle (i.e., 8th year) of the 26 experiments on mature tea spread over 13 sites of North East India was carried out during the year. The experiments were combined over sites within a region on the basis of the earlier groupings which were done after proper testing between sites. Results show more or less the same trend as in the previous years. *The important point that emerged from the results of these experiments was that requirement of phosphate was necessary every year at all the sites along with N and K.* However, the requiremnet of Nitrogen, Phosphate and Potash varied from place to place. Even the new set of 13 experiments which were started from 1977 onwards showed similar trend. However, the optimum combination of N, P and K could not yet be established with these set of experiments.

The old series of 26 experiments started in 1973-'74 were discontinued at the end of 1982 season after completion of 3 pruning cycles.

(b) **Long-term NPK experiment**

Yield data from long-term responses to N, P and K as influenced by organic manure application or mulching for clonal mature tea under shade started in 1982 were collected during the year and these are being processed for analysis. The experiment was planted in a Split-plot Confounded Factorial Design consisting of 512 plots at Tocklai Division.

(c) **Survey**

A survey was conducted in 1981 through mailed questionnaire sent to all the member and non-member tea estates of North East India to collect information on sectional yield for 1978, 1979 and 1980 and some important factors affecting the productivity of tea. The response was received from 250 tea estates covering about 10,000 sections. Some results were reported by the Director at the 29th Tocklai Conference held in November, 1981. Further analysis from this survey on distribution of area under tea by age, vacancy with corresponding loss of crop and use of clones revealed the following important features:

(i) The extent of existing vacancy showed that over one quarter (27.8%) of the total area under tea in the plains of North East India had vacancy over 10% with a corresponding loss of crop ranging from 21 to 53 per cent (Table 11.07). Also, the relationship between yield and vacancy is graphically presented in Fig. 11.01. This loss might not be due to vacancy alone, but it might be the combined effect of other

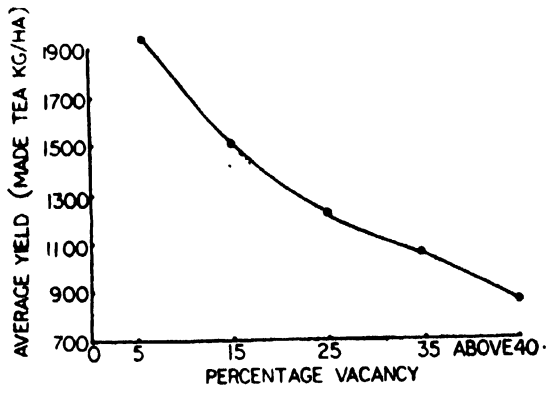


Fig 11.01. Relationship between yield and vacancy

Table 11.03. *Monthly maximum rainfall (cm) for 5-year return period with lower and upper limits for 95% probability level : 1957-74*
Circle : Nowgong (South Bank, Assam)

	MONTH																				
	October			November			December			January			February			March			April		
Tea Estate	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)
Amluckie T.E.	12.76	9.67	15.85	2.96	1.96	3.97	1.35	0.76	1.93	3.31	1.96	4.67	2.82	1.77	3.87	7.58	5.06	10.10	17.53	13.14	21.93
Jiajuri T.E.	17.96	12.26	23.66	3.95	2.49	5.41	1.04	0.53	1.54	4.30	2.44	6.15	3.18	2.04	4.32	8.74	5.89	11.59	17.84	13.74	21.95
Kellyden T.E.	14.65	10.98	18.33	3.45	2.11	4.79	1.34	0.74	1.95	4.10	2.38	5.82	4.02	2.43	5.62	8.87	5.95	11.80	21.30	15.84	26.76
Loongsoong T.E.	17.15	11.16	23.14	3.05	1.89	4.20	1.29	0.60	1.98	3.98	2.32	5.64	2.73	1.68	3.79	7.28	4.76	9.80	19.04	13.45	24.62
Sagmootea T.E.	14.45	10.53	18.37	4.10	2.44	5.76	1.82	1.13	2.51	3.97	2.42	5.52	3.30	2.12	4.48	7.98	5.26	10.69	22.16	16.88	27.45

Table 11.04. *Monthly maximum rainfall (cm) for 5-year return period with lower and upper limits for 95% probability level: 1957-72*
Circle : Jorhat (South Bank, Assam)

	MONTH																				
	October			November			December			January			February			March			April		
Tea Estate	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)
Hoolungooree T.E.	21.49	14.59	28.39	4.87	2.62	7.12	3.01	1.43	4.58	4.14	2.50	5.79	5.79	3.98	7.95	10.10	6.53	13.68	23.51	17.61	29.40
Kakajan T.E.	18.36	12.44	24.27	4.68	2.70	6.67	2.26	1.16	3.35	3.55	2.09	5.02	6.76	4.42	9.09	9.12	5.67	12.57	41.66	22.80	60.53
Naganijan T.E.	18.56	14.05	23.08	5.20	2.80	7.59	2.15	1.10	3.19	3.61	2.31	4.91	6.60	4.40	8.80	10.91	6.85	14.97	25.21	18.88	31.53
Soraipani T.E.	17.93	13.19	22.67	4.78	2.81	6.75	2.19	1.08	3.30	3.46	2.04	4.89	5.78	3.59	7.97	10.27	6.36	14.18	22.14	16.53	27.76
Heeleakah T.E.	17.91	12.51	23.32	3.27	1.84	4.70	2.90	1.47	4.34	3.27	1.85	4.69	5.75	3.76	7.73	9.53	6.10	12.97	21.91	16.40	27.42
Tyroon T.E.	18.95	12.78	25.12	4.60	2.34	6.85	1.96	0.94	2.98	3.66	2.26	5.05	5.35	3.33	7.37	10.20	6.27	14.13	22.03	16.21	27.84

Table 11.05. *Monthly maximum rainfall (cm) for 5-year return period with lower and upper limits for 95% probability level: 1957-'78*
Circle: Mangaldai (North Bank, Assam)

Tea Estate	MONTH																					
	October			November			December			January			February			March			April		
	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)
Borengajuli T.E.	16.63	11.24	22.01	3.74	2.21	5.26	2.10	1.27	2.93	2.94	1.86	4.01	3.21	2.13	4.28	9.83	6.84	12.81	31.93	22.72	41.15
Bhooteachang T.E.	19.53	13.26	25.80	5.05	3.90	6.21	4.44	2.36	6.52	3.40	2.12	4.67	3.48	2.26	4.70	9.61	6.91	12.32	29.52	21.79	37.25
Budlapara T.E.	20.99	13.77	28.20	3.83	2.30	5.36	2.26	1.31	3.21	3.59	2.32	4.86	3.92	2.47	5.36	10-59	7.46	13.72	31.63	24.09	39.16
Pancery T.E.	18.11	12.59	23.62	4.41	2.76	6.05	2.56	1.55	3.57	2.85	1.80	3.89	3.31	2.19	4.43	10.40	7.41	13.39	32.84	24.28	41.40

Table 11.06. *Monthly maximum rainfall (cm) for 5-year return period with lower and upper limits for 95% probability level: 1957-'74*
Circle : Borsola (North Bank, Assam)

Tea Estate	MONTH																					
	October			November			December			January			February			March			April		
	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit) (cm	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum Rainfall (cm)	Lower limit (cm)	Upper limit (cm)
Belseri T.E.	14.67	10.53	18.80	3.78	2.20	5.36	1.67	0.89	2.46	3.14	1.94	4.33	2.93	1.83	4.03	8.26	5.64	10.87	18.03	13.06	22.99
Julia/Tinkharia T.E.	15.68	10.98	20.39	4.59	2.51	6.67	2.19	1.16	3.23	4.23	2.43	6.04	3.79	2.39	5.19	10.19	6.89	13.50	25.98	19.72	32.23
Narayanpur T.E.	13.65	9.24	18.06	3.82	2.17	5.46	1.26	0.68	1.84	3.30	1.96	4.65	3.41	2.15	4.67	9.00	6.32	11.68	22.69	17.05	28.29
Deckiajuli*	13.54	9.11	17.97	5.64	2.94	8.35	1.33	0.72	1.94	3.81	2.20	5.42	3.87	2.33	5.41	10.51	6.97	14.05	28.06	19.73	36.39

* The analysis of Deckiajuli T.E. is based on 17 years (1958-'74) data.

Table 11.07. *Percentage area under tea in the plains (A) of North East India by vacancy percentage and corresponding loss of crop*

Description	Vacancy percentage	-<10	11-<20	21-<30	31-<40	>40
Percentage area		72.2	17.3	6.3	3.0	1.2
Estimated loss of crop (in percent)		10.5	20.9	35.6	42.6	53.1

(A) Excluding United Mikir Hills, Tripura and Darjeeling.

management factors which were confounded with vacancy.

(ii) Cumulative percentage area under tea by age shows that about 50% of the total area under tea in the plains of North East India are above 30 years old (Fig. 11.02). Further, it can be seen from Table 11.08 that average vacancy was higher (11.6%) than comparatively younger tea (7.2%). The over-all vacancy was found to be about 9.4 per cent. This adversely affects the productivity of tea; the per-hectare loss in productivity being about 7.3 per cent in the plains of North East India.

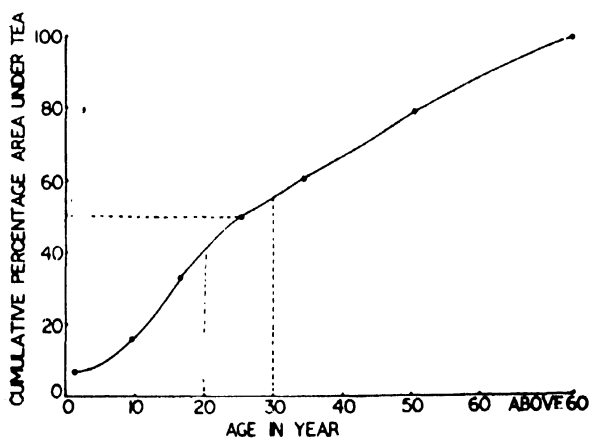


Fig 11.02. Cumulative percentage area under tea by age

(iii) Regarding the use of clones in North East India it was found that about 11 per cent of the total area under tea was under clone where both Tocklai and Tea Estates released clones were used.

Table 11.08. *Estimated percentage area under tea, vacancy percentage and corresponding loss of crop by age group in the plains (A) of North East India*

Age group (years)	Area (in percent)	Weighted average vacancy (in percent)	Per-hectare loss of crop due to vacancy (in percent)
-≤6	7.8	7.1	4.1
7—≤12	8.6	7.8	6.2
13—≤20	17.2	6.6	3.1
21—≤30	17.0	7.3	4.3
31—≤40	9.2	11.4	9.8
41—≤60	18.7	11.6	9.8
Above 60	21.5	11.8	11.5
Total/overall	100.0	9.4	7.3

(A) Excluding United Mikir Hills, Tripura and Darjeeling.

Statistical Service Function

Statistical planning, designing, arrangements of blocking on the basis of pre-treatment yields to minimise the variation between plots within a block, and randomisation for different research projects were carried out for about 35 new experiments from various departments. Method of analysis was also determined for a large number of experiments to extract maximum information and draw valid conclusions from these experiments. In addition to these, statistical method of analysis was determined for Ph.D. thesis also.

Data Processing

Field and laboratory experimental records for 1981 and 1982 on computerised proforma poured in practically from all the research departments and from the member estates of North East India. Weekly/monthly/yearly yield and other experimental records from about 400 experiments were received during the period. These records were checked, punched and verified on the Unit Record Machines at Tocklai. Computations of about 200 analyses were carried out on the Unit Record Machines at Tocklai and on the Electronic Computers at the R.C.C., Calcutta and A.O.C., Digboi. In this connection, computer programmes were written in FORTRAN-IV language for computations of the complex problems on the Electronic Computer. In addition to these, accounts jobs and quarterly T.R.A. membership subscription statements were also prepared on the Unit Record Machines.

Highlights

The productivity gap between TRA members is narrowing down in each sub-area with more effective implementation of Tocklai recommendations. 5 estates in Darjeeling attained yield more than 1000 kg/ha and 93 estates of Assam Valley, Dooars and Terai achieved more than 2000 kg/ha yield in 1981.

The average plucking productivity in Cachar is much lower but the difference between fast and slow plucker is found only about 25% which was found much higher in other regions of N.E. India. There is much scope of improving pluckers productivity in Cachar.

TRA Member Estate Productivity in 1981

In view of the size and importance of North Eastern Indian tea industry as a landholder, employer and exporter, the productivity survey is essential since it gives an idea the way the growth has taken place and indicates steps to achieve higher target fixed for the future.

The area production and yield data from 381 TRA (responding) member estates form the basis of sub-area average yield for 1981. The member estates can compare their performance with the average of the sub-area. The distribution pattern of yield for different estates in each area have also been shown. It is expected that low yielding estates will increase their yield at a faster rate in future to catch the high yielding estates of their sub-areas.

Table 12.01. *Regionwise Area, Production & Yield of TRA member estates, 1981.*

Regions	No. of responding estates	Area ha	Production Kg. (lakh)	Yield Kg/ha
Darjeeling	43	10,790	83.29	772
Terai	18	4,392	80.19	1826
Dooars	67	31,283	555.41	1807
North Bank	67	28,755	526.57	1831
Upper Assam	97	38,383	783.33	2041
Central & Lower Assam	63	22,771	322.09	1414
Cachar & Tripura	26	9,836	130.59	1329
Total N.E. India	381	1,46,210	2491.47	1704

Table 12.02. *Sub-area yield and No. of Estates under different yield levels in each sub-area for 1981.*

Sub-area	No. of responding estates	Average yield kg/ha	Yield levels kg/ha				
			Below 400	400 to 600	600 to 800	800 to 1000	Above 1000
Darjeeling Central	5	778	—	1	2	1	1
Darjeeling East	6	877	—	—	2	3	1
Darjeeling West	6	660	—	3	1	2	—
Teesta Valley	6	949	—	1	—	4	1
Sonada	7	601	—	5	1	1	—
Rungbong	4	808	—	1	1	2	—
Tingling	4	857	—	—	1	2	1
Kurseong	4	826	—	3	—	—	1
Mahanady	1	476	—	1	—	—	—
Total Darjeeling	43	772	—	15	8	15	5

Sub-area	No. of responding estates	Average yield Kg/ha	Below 1000	1000 to 1200	1200 to 1400	1400 to 1600	1600 to 1800	1800 to 2000	2000 to 2200	Above 2200
Terai	18	1826	1	2	1	3	2	5	1	3
Jainti	7	1912	—	—	—	—	2	2	3	—
Kalchini	7	2081	—	—	—	—	1	3	1	2
Dalgaon	7	1740	—	—	1	—	4	2	—	—
Binnaguri	10	1798	—	—	—	1	1	3	1	1
Nagrakata	6	1614	1	—	1	1	1	1	1	—
Chulsa	10	1836	—	—	1	1	3	2	2	1
Dam Dim	20	1722	1	2	4	3	4	1	1	4
Total Dooars	67	1807	2	2	7	6	19	14	9	8
N. Lakhimpur	7	1648	—	—	1	—	4	2	—	—
East Boroi	10	1920	1	—	—	1	1	2	4	1
Bishnauth	8	1948	—	—	—	—	3	3	1	1
Tezpur	13	1741	—	—	2	4	1	4	2	—
Borsola	4	1632	—	—	1	2	—	1	—	—
Orang	5	1794	—	—	—	—	3	1	1	—
Mangaldoi	14	1939	1	—	1	—	3	3	3	3
Goalpara	6	1826	1	—	—	3	—	—	1	1
Total N. Bank	67	1831	3	—	5	10	15	16	12	6

Sub-area		No. of responding estates	Average yield Kg/ha	Below 1000	1000 to 1200	1200 to 1400	1400 to 1600	1600 to 1800	1800 to 2000	2000 to 2200	Above 2200
Doom Dooma	A	7	1901	—	1	—	—	2	—	3	1
	B	6	2229	—	—	—	—	—	1	1	4
	C	4	1916	—	—	—	—	2	1	1	—
	D	7	2056	—	—	—	—	1	2	2	2
Dibrugarh	A	7	1938	—	—	—	2	1	2	2	—
	B	7	2140	—	—	—	—	1	—	3	3
	C	6	2238	—	1	—	—	—	—	1	4
Panitola	A	6	2095	—	—	—	—	—	3	2	1
	B	3	2322	—	—	—	—	—	—	1	2
Nahorkatia	A	6	1913	—	—	—	—	2	3	1	—
	B	7	1897	—	—	—	2	2	—	2	1
Moran	A	7	1698	1	—	—	2	1	—	4	—
	B	9	1934	—	—	—	—	2	2	3	1
Tingrai	A	8	2202	—	—	—	—	2	2	—	4
	B	7	1956	—	—	1	1	—	1	3	1
Total Upper Assam		97	2041	1	2	1	7	16	17	29	24

Sub-area		No. of responding estates	Average yield Kg/ha	Below 1000	1000 to 1200	1200 to 1400	1400 to 1600	1600 to 1800	800 to 2000	2000 to 2200	Above 2200
Sonari & Nazira	A	5	1637	—	—	—	2	1	1	1	—
	B	4	1528	—	—	3	—	—	1	—	—
	C	4	1370	—	2	—	2	—	—	—	—
Jorhat	A	5	1334	—	1	1	2	—	—	—	—
	B	10	1288	1	2	3	3	2	—	—	—
	C	6	1278	2	—	1	2	—	—	—	—
Golaghat	A	9	1578	1	—	—	3	5	1	—	—
	B	7	1279	2	2	—	2	1	—	—	—
	C	5	1534	—	—	1	2	3	—	—	—
Nowgong		8	1444	1	—	2	1	1	1	—	—
Total Central & Lower Assam		63	1414	7	7	11	20	13	4	1	
Hailakandy		7	1300	—	2	3	1	—	1	—	—
Karimganj		3	1020	1	2	—	—	—	—	—	—
Longai		4	1746	—	—	—	1	1	2	—	—
Happy Valley	'A'	4	1343	2	—	1	—	1	—	—	—
	'B'	4	1087	1	2	1	—	—	—	—	—
Chutta Bheel		3	1466	1	—	1	—	1	—	—	—
North Cachar		1	966	1	—	—	—	—	—	—	—
Tripura											
Total Cachar & Tripura		26	1328	6	6	6	2	3	3	—	—

Work study in Cachar

Work study on plucking operation was taken up in Cachar in three tea gardens during the harvesting season of 1981. Some of the factors influencing Plucker productivity were studied and disparities in productivity among the pluckers in a garden and between the gardens were noticed.

It was observed that the efficiency of pluckers in terms of shoots plucked per unit time depended mainly on availability of shoots on bush and shoot weight. Though high density of shoots increased the plucking speed, heavy shoots act in the reverse way.

Table 12.03. *Productivity of estates - July to October*

Estate	Bushes plucked per hour	Shoot weight in gm	Shoots plucked per minute	Shoots per bush	Effective hours	Total Kg. plucked/ day
A	45	1.28	80	120	4.00	25
B	54	1.05	78	87	4.11	20
C	78	1.66	67	62	3.37	23

It was found that bushes of estate A produced maximum number of shoots followed by B and C. Hence shoots plucked per minute was maximum in A followed by B and C.

The effect of shoot weight on effective hours of working was significant. In estate B, though availability of shoot was 28% less than estate A, the effective hours of working was 3% more because the shoot weight of estate B was 18% less than A. Similarly, in estate C, though the density of shoot was 29% less than B (almost same percentage as in case of A & B), they plucked for 18% less effective time as because of plucking of 37% heavier shoots.

It was noticed as shown in Table 2 that with the advance of the season, availability of shoots on bush decreased, resulting in decreased plucking speed and quality of crop harvested per day. Shoot weight in August and September increased by 4% than July, but dropped by 28% in October.

Fast pluckers plucked 19% more crop than slow pluckers by working 2% more time and 19% faster.

Table 12.04. *Seasonal effect on productivity*

Month	Shoots per bush	Shoots plucked per minute	Shoot weight	Effective hours	Total Kg. plucked/day
July	115	89	1.28	3.57	24.7
August	87	74	1.33	4.04	24.1
September	100	73	1.32	3.95	22.3
October	77	79	0.92	3.76	15.9

It seems that the difference of output was mainly due to plucking speed, which was also reflected by productivity difference of fast and average pluckers. Though average workers' effective working time was about 3% more than fast pluckers, their output was 13% less because of 15% less plucking speed.

Table 12.05. *Productivity of Fast, average and Slow pluckers*

Rating	Bushes plucked per Hour	Shoots per bush	Shoot weight in gms	Shoots plucked per minute	Effective hours	Total Kg. plucked per day
Fast	65	93	1.35	81	3.93	25.55
Average	61	84	1.37	69	4.03	22.21
Slow	58	86	1.38	66	3.84	20.73

Efficiency of all grades of pluckers was minimum in estate C. Even the slow pluckers of estate A plucked more shoots per minute than the fast pluckers of estate C.

Difference of productivity between fast and slow pluckers was found in all the three gardens which was minimum in garden A and much pronounced in garden B. In garden B, the difference of plucking speed was as high as 21%. In the three gardens 6 to 12 % pluckable shoots were left unplucked by the slow pluckers.

Utilisation of time for various activities related to plucking were studied in estate B and C. Total time spent in the field ranged from 8.00 hrs. to 8 hrs. 39 minutes. Almost equal time (63 to 66% of total time) was utilised for plucking operation by all grades of pluckers, except the slow group of pluckers of estate B. They utilised only 57% of the total time which can be attributed to their more time spent for rest pause and late arrival in the plucking section. The consumption of time for weighment was 7 to 17% in estate B and 7 to 13% in estate C. There is scope for reducing the weighment time by providing more weighing points nearer to the plucking section and by efficient weighing methods. Table 12·06 shows the average time utilisation in two estates.

Table 12.06. *Utilisation of time by pluckers - Average of three ratings of two estates*

	Activity	Hrs. — Min.	% of total time
1.	Arrival	0 — 18	4
2.	Preparation	0 — 07	1
3.	Plucking	5 — 19	63
4.	Emptying	0 — 28	6
5.	Rest pause	0 — 41	8
6.	Lunch	0 — 31	6
7.	Weighment	0 — 50	10
8.	Departure	0 — 08	2
	Total	8 — 22	100

It is expected that there is scope for increasing the efficiency of average and slow pluckers by around 10%, if training for proper plucking method is given to them and the required supervision is maintained.

Nagrakata Sub-Station

SOILS AND METEOROLOGY

Summary

Steady increase in yield was maintained as a result of reclamation of insufficiently acid soil by application of Pyrites and Aluminium Sulphate at various rates. A comparative assessment of growth and development of young tea treated with Single super phosphate and Rockphosphate plus Pyrites shows that the later treatment caused a better root and shoot development.

Autumn Vs Spring application of Rock phosphate @ 20 kg/ha and 40 kg/ha shows appreciable increase in green leaf with 20 kg autumn application over comparable treatment in spring.

Laboratory studies on phosphate fixation on soils from Low-P and High-P areas were carried out. Preliminary studies were also carried out on the aspect of potash build up in soils collected from various locations.

Reclamation of insufficiently acid soil under mature tea

Soil pH values in the plots treated with aluminium sulphate and pyrites have been stabilised in the optimum range as a result of second application in April '82. Yield records from these plots during May-November '82, marked an overall increase, ranging between 11 to 26 per cent over control. Plots treated with pyrites @ 4T/ha record 26 per cent gain over control followed by 17 per cent gain in aluminium sulphate treated plots at the same rate. Plots treated with higher doses (8 tonnes and 12 tonnes/ha) also record an increase of 11 to 15 per cent over control.

Gypsum treated plots did not receive second application as the pH values were found to increase after first application. However the plots treated with 4T/ha indicated a marginal rise in yield over control although there is depression in yield at higher rates of application.

Plucked shoots collected once every month from individual plots are being chemically analysed with a view to find out the pattern of uptake of the major nutrients as a result of soil pH correction.

So far the results suggest that : (i) Pyrites seems to be the most effective chemical for correction of under-acid soil and (ii) for sandy loam type of soil with pH values between 5.80 and 6.20, application rate at 4T/ha/annum is considered enough for pH adjustment to the optimum range. Application at higher rates is not preferred as this may lead to undesirable side effects.

Possibility of using rock phosphate in young tea

This experiment was conducted in pots with TV18 plants using S.S.P. and Rock phosphate (Mussorie Phos) mixed with pyrites in 4:1 proportion for a comparative study. Growth parameters were measured at regular interval after transplanting in May '82 for nearly a year. A statement of total growth during this period is given in the following table:

Growth parameters	Rock P + Pyrites	S.S.P.
Length	39.3 cm	33.5 cm
Girth	1.35 cm	0.93 cm
No. of laterals	29	23

The plants were taken out from the pots in April '83 and weight of different components are shown below:

	Shoot wt * (gm)	Root wt * (gm)	Total wt * (gm)	Shoot / Root
Rock P + Pyrites	90	38	128	2.3
S.S.P.	65	24	89	2.7

* Expressed on dry weight basis

Plants treated with Rock phosphate + Pyrites have better shoot and root development and lower shoot/root ratio also suggests that Rock phosphate application has encouraged healthy root growth.

Total recovery of the applied nutrients by the plants are now being estimated. The results are being varified under actual field condition with TV1 and TV18 plants transplanted at Nagrakata trial plot.

Optimum time of Rock phosphate application in Mature tea

It is known that response of the plants to applied fertiliser depends on the growth dynamics of the roots. Since root growth varies seasonally, experiments were taken up to find out the most optimum time for efficient absorption of phosphates by the roots.

In the first phase of the study, rock phosphate (Mussorie Phos) was applied (@) 20 kg and 40 kg P_2O_5 per hectare in October '81 on Assam type of bushes about 15 year old. In May '82 a similar set of plots were treated with rock phosphate at identical rates. Yield records were regularly maintained with a view to study the yield pattern of the plots treated with rock phosphate at different times of the year.

Following are the total yields of different treatments during the cropping period April—November, 1982:

	Green leaf wt.
A. Autumn application	
@ 20 kg P_2O_5 /ha —	19.35 kg
@ 40 kg P_2O_5 /ha —	17.09 kg
B. Spring application	
@ 20 kg P_2O_5 /ha —	17.71 kg
@ 40 kg P_2O_5 /ha —	19.54 kg

There is a crop gain of over 9 per cent in 20 kg Autumn plots over 20 kg Spring plots. Yield in 20 kg Autumn plots and 40 kg Spring plots are similar. The reason for lowest yield in 40 kg Autumn plots is not clear.

There has been an appreciable reduction of available soil phosphate values in the plots receiving 20 kg P_2O_5 /ha in Spring. Regular analysis of plucked shoots was carried out during the cropping period and percentage of potash and phosphate uptake was found to be similar in the treatments. (% P_2O_5 values range between 0.83--0.84 and % K_2O values range between 2.52—2.55).

Plucking point density per bush was measured and dry weight of 100 plucked shoots (two and a bud shoot) were also taken during the season and the results are given below :

	Average plucking point density/plot	Dry wt of 100 plucked shoot
20 kg- Autumn	142	13.62 gm
40 kg - Autumn	102	13.49 gm
20 kg - Spring	76	13.41 gm
40 kg - Spring	120	13.61 gm

It can be seen from the above table that plucking point density and wt of 100 plucked shoot is highest in case of 20 kg Autumn plots and lowest in case of 20 kg Spring plots.

Studies on Phosphate fixation

With a view to measure the degree of phosphate fixation in low phosphate areas (<20 ppm P_2O_5) and high phosphate areas (50 ppm> P_2O_5), number of soil samples were collected from such areas and applied with S.S.P. at the rate of 20 kg, 45 kg, 90 kg, 180 kg and 360 kg P_2O_5 per hectare. The amount of applied phosphate fixed in the soil after 96 hours of incubation under laboratory condition was estimated and the general trend of fixation pattern for both these areas are shown in the table.

The quantity of applied phosphate fixed in high phosphate areas is significantly less than that in low phosphate areas and there is gradual decrease in percentage fixation with increasing doses of applied phosphate. In case of low phosphate areas percentage fixation increases upto 90 kg application rate and then decreases with higher rates of application.

Phosphate application rate P_2O_5 kg/ha	High-P area (> 50 ppm) Amount P_2O_5 fixed	% fixation	Low-P area (< 20 ppm) Amount P_2O_5 fixed	% fixation
20	5 kg	25	5 kg	25
45	10 kg	20	20 kg	40
90	10 kg	10	45 kg	55
180	20 kg	10	75 kg	45
360	35 kg	10	125 kg	40

The results include soils from Dooars, Terai and Darjeeling areas. It is now contemplated to carry out this study on regional basis so that more precise information could be obtained for each region.

Studies on the behaviour of potash build-up in soil

Soils low in available potash respond differentially with corrective potash dressing at the required rates. As a result potash build-up widely different in different areas. Several soil samples from such areas were collected and applied with m.o.p. at required rates in an attempt to study the rate of potash fixation in these soils.

Both short term incubation (72 hours) and long term incubation (2 months) methods were tried in the laboratory and the amount of potash fixed is found to range between 9 to 31 per cent by short term method and 16 to 50 per cent fixation by long term method. The results so far obtained are not conclusive yet and the work is in progress with samples from high phosphate and low phosphate areas which are commonly associated with low and high potash (available) respectively.

As an extension of this study in the field, few low potash section those are high in available P_2O_5 have been selected in 4 Terai gardens and following m.o.p. application in these plots, samples are being analysed at regular interval for both exchangeable and non-exchangeable potash fraction for the purpose of obtaining some information regarding fixation and release mechanism of applied potash.

ADVISORY SERVICES

Soil Analysis

More than 12,000 soil samples were analysed for pH, nitrogen, organic matter and eelworm from extension, replanting and nursery areas. Most of these samples were also analysed for available potash and phosphate for manuring purpose.

In addition analysis of leaf samples were carried out from time to time for suspected deficiency of major nutrients.

Meteorology

Met data collected from 4 Met Stations located in Darjeeling, Terai and Dooars are being utilised for

developing crop correlationship and for estimating irrigation needs of different estates in Dooars and Terai. Long term met data are also being analysed to find out the periodicity of drought in Dooars and Terai region.

New Members: Red Bank Tea Estate joined on 1st October 1982.

Advisory visit

No- of visits paid during 1982-83	No. of estates visited during 1982-83	Total No. of Member estates
268	—	85 (Dooars 77 + Goalpara 8)

Area Scientific Committee meeting

(1) 1st June 1982

Seminars

Engineering and manufacture - 1st June 1982

Sub-District Seminars

Kalchini Sub-District-16th September 1982

Seminar of Gurjangjhora Tea Co.- 7th & 8th May 1982

Field management work shop on 4th March 1983.

Field Training course

Two demonstrations on spraying were held in Dooars.

Agricultural practices

Land planning and drainage

Laying out of the drainage system on the basis of level survey continued to be popular amongst member estates. However, advice was given to do away with the level survey for areas having slope less than 3%.

Pruning cycle

There was a tendency towards crop oriented pruning cycle. Though, in general, the four year cycle continued to be popular, but the gardens with adequate irrigation facilities have gone for a cycle with more unpruned/lighter forms of skiff.

New Extension/Uprooting/Replanting and rejuvenation with Infilling

Emphasis was laid on new extension planting where adequate land is available. Otherwise rejuvenation with infilling was gained popularity. Infilling with double hedge was tried by a number of estates. Though the importance of uprooting and replanting was realised, by and large the progress has remained slow.

Manuring

By and large the estates could apply adequate manures.

Potash application on the basis of soil analysis report was continued.

Rockphosphate continued to gain popularity. However, caution was observed in situations where the soil pH is in the border line.

Foliar spraying of either urea, Potash, Zinc sulphate or any other micro nutrients did receive usual attention.

Weed control

Pre-emergent herbicide like Karmex and Simazine was found to be popular. Paraquat and 2,4-D remained popular although in young tea areas, against thatch Glyphosate was used in many estates.

Pest Control

There was sudden resurgence of red spider and this pest has done considerable damage. Purple and pink mites was a problem in the early part of the year under review.

In some areas Red slug and Looper caterpillar appeared in epidemic form in the early part and became the cause of concern.

Evidence of cockchafer was noticed in the young tea areas, however this year its impact was much less.

Infestation of thrips was rather heavy in most of the areas and this pest has caused some loss of crop.

White ants continued to be present mostly in red bank soils and control measures were undertaken by the estates.

Disease control

Both red rust and black rot were found in localised patches. These were controlled promptly.

Plucking

Standard plucking continued to be popular. However more stress was laid in finer plucking for quality.

Vegetative propagation

The area under clonal nursery has increased, and estates due to short supply of biclonal seeds have gone for vegetative propagation. North light over head shade continued to be popular.

Planting Materials

TV 18 and TV 20 remained popular clones but more and more attention was given to newly released clones like TV 22, TV 23, TV 24, TV 25 and TV 26.

Shade

Efforts have continued to reshade the gardens and the following spp. were popular among the estates:

Albizzia odoratissima
Albizzia lebbek
Acacia lenticularis
Derris robusta

Biotic disturbances like damage by workers, outsiders, cattle trespass, remained the limiting factors. Under planting of Indigofera remained popular. In few gardens mostly in Central Dooars area, sudden death of mature odoratissima shade trees were noticed. Large

scale damage of this spp. was also noticed by leaf eating caterpillars.

Young tea

A plant population between 14000-16000 plants/ha remained popular. Most of the estates have followed the low tipping method of bringing up of young tea, as pegging did not receive much attention.

Mulching, was not very popular due to its high cost and unavailability of suitable vegetative matter, though its importance was felt by all estates.

Experiments

21 field experiments and 8 R & D experiment were in progress during the year under review.

The list of experiments are given below:

R & D trials of Duncan Agro Industries:

(1) NPK trial - 719 Killcott Tea Garden
(2) Plucking trial - 706 -do-
(3) Pruning vs. plucking trial - 708 Nagaisuree TG
(4) Maintenance foliage trial - 722 -do-
(5) Dolomite trial - 710 Samsing Tea Garden
(6) NPK trial - 721 Baintgoorie Tea Garden
(7) Foliar spray of urea - 712 Bagrakote Tea Garden
(8) Ratio manuring trial - 711 -do-

List of the experiments on Tea Estates in Dooars and Terai during 1982-83.

Sl. No.	Project	Site	Index No.	Year of starting
1.	Shade Vs. Nutrition trial	Satali T.E.	D 78	1978
2.	Young tea manuring (Response surface NPK)	Lakhipara T.G.	D 68	1977
		Bhogotpur T.E.	D 69	1977
3.	Times of pruning/skiffing	Baradighi T.G.	D 83	1980
		Baradighi T.G.	D 84	1980
		Baradighi T.G.	D 85	1980
4.	Reduction of N	Gandrapara T.E.	D 92	1982
		Gandrapara T.E.	D 93	1982
		Hansqua T.G.	TR94	1982
		Hansqua T.G.	TR95	1982
5.	*NPK manuring of mature tea	Bagrakote T.G.	D 55	1973
		Sam Sing T.G.	D 56	1973
		Nimtijhora T.E.	D 57	1973
		Gungaram T.G.	TR 7	1973
6.	*Young tea manuring (YTD)	Nagrakata T.E.	D 65	1977
		Nagaisuree T.E.	D 66	1977
7.	*Rejuvenation Trial	Dalgaon T.G.	D 43	1972
		Matelli T.G.	D 44	1972
		Rydak T.G.	D 46	1972
		Kumlai T.E.	D 47	1972
		Gungaram T.G.	TR 5	1972

*Discontinued after 1982

The trend of some of the experiments have been summarised below:

(1) *Rejuvenation Trial (Results of 1981 are given below)*

Treatments	D 46 Rydak MT KG/HA	TR 5 Gungaram MT KG/HA	D 43 Dalgaon GL KG/TR	D 44 Matelli MT KG/HA	D 47 Kumlai MT KG/HA
T_1– No rejuvenation (Control)	1459.44	2083.93	406.88	1779.07	1226.86
T_2– Cold. weather Rej. prune and infill in the spring with 106/1 at double the No. of plants per vacancy plus one.	2028.49	2557.66	517.05	1983.75	1765.46
T_3– Cold. weather Rej. prune and infill and interplant in spring with 106/1 to make into hedge	1969.00	2860.73	641.78	1923.81	1459.79
T_4– Rej. prune in July/August & infill in the autumn as in T_2	1671.46	2745.97	466.87	1781.71	1458.12
T_5–. Rej prune in July/August and infill in the autumn as in T3	2024.12	2788.77	533.95	2052.23	1485.29
LSD–P 5%	391.88	63.09	24.65	283.43	379.18
1%		104.63	40.89		
1%		195.68			
CV%	7.76	0.87	1.73	5.36	9.23

From the table it is seen that in D 43 all the rejuvenated treatments gave significantly higher yield than control. Among the treatments T_3 gave significantly the highest yield. Treatments T_2 and T_5 also gave significantly higher yield over T_4.

In D 44 although rejuvenated treatments gave higher yield over control but there was no significant difference.

In D 46, rejuvenated treatments gave higher yield over control. T_2, T_3 and T_5 produced significantly higher yield. But there is no significant difference in yield among the treatments.

In D 47, though rejuvenation treatments produced significantly higher yield over control. The yield of T_4 and T_5 are at par but significant over T_2. T_3 produced the highest yield among the treatments.

Soil Rehabilitation Trial (D 27)

This trial was to study the effect of different systems of rehabilitation of land for planting of tea on the growth and yield of hedge planted tea and was laid out in the year 1964.

The results of 1981 was as under.

Treatments	Green leaf in kg/plot
T_1 - Tea uprooted in December 1965/ January 1966. After sub soiling and deep ploughing tea replanted in spring 1966.	168.12
T_2 - Tea uprooted in December 1965/ January 1966. No sub soiling and deep ploughing. Tea replanted in spring 1966.	174.51
T_3 - Tea uprooted in December 1964/ January 1965 followed by heavy green cropping for one year. Land sub soiled and deep ploughing. Tea replanted in spring 1966.	163.79
T_4 - Tea uprooted and green cropping as in T_3. No sub soiling and no deep ploughing. Tea replanted in spring 1966.	168.95
T_5 - Tea uprooted in January 1964 followed by heavy green cropping for two years. Land sub soiled and deep ploughed. Tea replanted in spring 1966.	184.70
T_6 - Tea uprooted and green cropping as in T_5. No sub soiling & no deep Ploughing Tea replanted in spring 1966.	169.09
CD at 5%	22.25
CV%	7.79

This trial was continued to see if and when the differences between the rehabilitation treatments are evens out. 1981 data, showed no significant differences between rehabilitation treatments. But T_5 which is the standard practice produce the higher yield.

Shade Vs Nutrition (D 78)

To compare the yield of tea under different shade regimes and to determine, the differential response to NPK under varying shade regimes, this trial was laid out in the year 1978.

Treatments - Main plot	Sub plot
M_1- Existing shade	S_1 - NPK 100,20,40 kg/ha
M_2- Lopped shade	S_2 - NPK 150,30,60 kg/ha
	S_3 - NPK 200,40,80 kg/ha
	S_4 - N 200

Results - The yield data under different treatments for 1981 is given below:

M. plot Tr. code	S1	S2	S3	S4	Mean
M 1	44.15	43.78	50.13	44.52	45.65
M 2	48.12	51.02	48.00	49.05	49.05
Mean	46.14	47.40	49.07	46.78	—
(1) Bet. two main plot treatment means					= 1.93
(2) Bet. two sub plot treatment means					= 3.83
(3) Bet. two sub plot as same main plot					= 5.42
(4) Bet. two main plot at same or					= 4.99
different sub plot CV%				(1)	= 2.30
				(2)	= 6.43

M_2 produced significantly higher yield over M_1. In between the sub plots within the main plots M_1 S_3 produced significantly higher yield over others. In between two main plots, within or different sub plots, M_2 S_2 is significant over M_1S_1 and M_1S_2. But M_2S_4 was found significant over M_1S_2 as seen above.

Shade Vs Nutrition Trial at Gandrapara Tea Garden (D 50)

Object: To compare the yield of tea under different shade regimes and to determine the differential response to NPK under varying shade regimes and started in the year 1973.

Treatments:

Main plot treatments	Sub plot treatments
M1 - No shade	S1 - NPK 100,20,40 kg/ha
M2 - Shade corrected by lopping	S2 - NPK 150,30,60 kg/ha
M3 - Existing shade	S3 - NPK 200,40,80 kg/ha
	S4 - N 200 kg/ha

Results : The yield data under different treatments are given in the table below:

Main plot × sub plot mean yield green leaf in kg/plot-1981

Main plot Tr. Code No. — Sub plot treatment code Nos.

	S1	S2	S3	S4	Mean
M1	77.00	74.08	76.30	67.48	73.72
M2	78.38	81.68	75.65	78.22	78.48
M3	82.58	75.00	69.80	76.72	76.02
CD			at 5%		
(1) Between two main plot treatment means—					13.81
(2) Between two sub plot treatment means—					7.14
(3) Between two sub plot treatment at same— main plot					12.37
(4) Between two main plot treatment at same or different sub plot				—	16.61
				C.V. (1)	8.44%
				(2)	7.19%

From the above table it is seen that M_3S_1 produced significantly higher yield over M_3S_3. The remaining treatments were found to be non-significant.

Soil climatological survey, Nya Sylee Tea Estate

Expt. No. D 24 Object

This experiment was started in 1962 to study the growth response of different kinds of tea under varying soil and climatic conditions and their response to different levels of nitrogen under varying environmental conditions. Five clones were planted in 1962 at a spacing of 4′ × 3′. The layout was a split plot design where four levels of nitrogen were applied on the whole plots and the sub plot treatments were applied on the whole plots and the sub plot treatments were five different clones. There were three replications and therefore, the whole experiment consisted of 60 plots.

Treatment details Sub-plot treatments - clones

Main Plot Nitrogen

M_1	No nitrogen	S_1 - 19/29/13	(TV1)
M_2	55 kg N/ha	S_2 - 20/23/1	(TV 2)
M_3	110 kg N/ha	S_3 - 1/7/1	(TV 3)
M_4	165 kg N/ha	S_4 - 107/4	(TV 18)
		S_5 - 3/22	

Results : The tea was under light pruned in 1981.

Yield of green leaf kg/plot

Main plot × sub plot mean yield

Main plot Tr. Code Nos.	Sub plot treatment code Nos.					
	S_1	S_2	S_3	S_4	S_5	Mean
M_1	29.38	14.70	14.10	36.08	12.63	21.38
M_2	45.37	23.98	26.93	56.15	30.42	36.57
M_3	46.90	35.03	35.13	67.87	38.60	44.71
M_4	52.10	38.97	30.20	74.48	42.80	47.71
Mean	43.44	28.17	26.59	58.64	31.11	

	C.D. (Green leaf in kg/plot)	At 5%
(1)	Between two main plot treatment means	3.74
(2)	Between two sub plot treatment means	4.17
(3)	Between two sub plot treatment means same M. Plot	8.34
(4)	Between two M. plot treatment at same or different sub plot treatments	8.33
	C.V. (1)	11.13%
	(2)	13.33%

All the three doses of Nitrogen gave significantly higher yield over no nitrogen (M_1). There is no significant difference in yield between M_3 and M_4, but both of these treatments gave significantly higher yield than M_2.

S_4 gave the highest yield and it significantly out yielded other clones. S_1 gave significantly higher yield over S_2, S_3 and S_5. S_2 and S_3 are at par whereas S_5 gave significantly higher yield over S_3 as can be seen in the table above.

All the clones under different doses of N (except M_2S_5) gave significantly higher yield than that under no nitrogen.

When the rate of N was raised from 55 upto 110 kg N/ha the yield of treatments S_2 and S_4 increased significantly.

There was, however, no significant change in yield in case of all the clones when the nitrogen dose was raised from 110 kg to 165 kg/ha.

Differential timing of Pruning/skiffing

Table : *Effect of seasonality on pruning/skiffing operati ns in the Doors.*

Time - Middle of each month	D 83 (DS)	D 84 (MS)	D 85 (LP)
(1) October	1923.70	1451.53	889.35
(2) November	1835.04	1498.36	783.35
(3) December	1941.54	1505.70	912.35
(4) January	1843.87	1622.53	987.35
(5) February (early)	1736.37	1767.54	1154.19
(6) February	1840.87	1581.03	1342.53
L.S.D. at 5%	203.50	147.34	150.50
CV %	9.21	7.69	12.36

From the above figure it is seen that in D 83 T_3 produced significantly higher yield over T_5.

In D84 T_5 gave significantly higher yield over other treatments, except T_4, which is significant over T_1.

In D85 T_5 and 6 gave significantly higher yield than others. T_4 is significant to T_2.

This was the second year of experiment and D 85 suffered a severe hail damage in that year.

Rejuvenation trial

The Results of 1982 are given below:

Treatments	Made t a in KG/HA TR 5	D 47
(1) Control (No Rejuvenation)	2577.46	1077.34
(2) Rejuvenation prune in cold weather. Infill in the spring with 106/1 at double the number of plants per vacancy plus one	3119.78	1595.69
(3) Rejuvenation prune in cold weather. Infilling and interplanting in spring with 106/1 to make into hedge.	3526.79	1538.42
(4) Rejuvenation prune in July- August. Infill in the autumn as in T_2.	3470.02	1503.01
(5) Rejuvenation prune in July/August. Infill in the autumn as in T_3.	3341.63	1570.04
C.D. at 5%	377.90	186.21
C.V. %	4.25	4.61

From the above data it is seen that in TR 5 all the rejuvenated treatments gave significantly higher yield over control and T_3 is significant over T_2.

In D 47 all the rejuvenated treatments gave significantly higher yield over control but there is no difference among the treatments.

WATER MANAGEMENT

A. DARJEELING

A research experiment has been taken up in Rungaroon Tea Estate on drainage. The land has very steep slope (48%) and has suffered from serious land slide and sinking during past. Due to this reason, the tea in some areas had to be abandoned.

The climatic, soil and hydrological data collected from the garden during 1982 have indicated that the major source of excess water causing serious waterlogging has been the seepage flow from high lands. The piezometers were installed to study the water table configuration in the experimental area before draining. The data on water table and rainfall plotted in figure 1 (A) and 1 (C) have clearly shown the buildup of water table very close to the ground level (Fig. 1A & 1C). The water table fluctuated within a very narrow i.e. 30 to 45 cm below the ground level irrespective of rainfall received during the period of August to October 1982.

Based on the data collected, a special drainage system technically referred to as 'Interception Drainage System' was designed and installed in the experimental area. This system of drainage differs significantly from that normally used for flat lands and is very difficult to design. The data on ground water table recorded after providing interception drains in the area have been plotted in fig. 1(B). The data have shown that the improved drainage system could effectively control the water table 90 cm below the ground level. Also no land slide and sinking has been observed in rained plot for last one year.

The experiment is in progress.

A similar field experiment on drainage has been taken up in Tukdah Tea Estate.

The data on water table and rainfall have indicated a similar relationship as shown in Figure 1.

B. TERAI

Design of open drainage system

A very badly waterlogged garden having almost no systematic drainage system has been selected for our experiment on design of open drainage system. The W.T. data have shown that during rains, the water table normally remained very near to the ground level before taking up the project. Based on the data collected on land topography, soil and climate, a net work of laterals, submain and main drains has been designed and installed in the project area covering about 300 acres of land. The new drainage system has been designed to control the water table 90 cm below ground level. To overcome the problem of erosion, several soil conservation structures have been designed and installed in the main drains. A set of piezometer wells

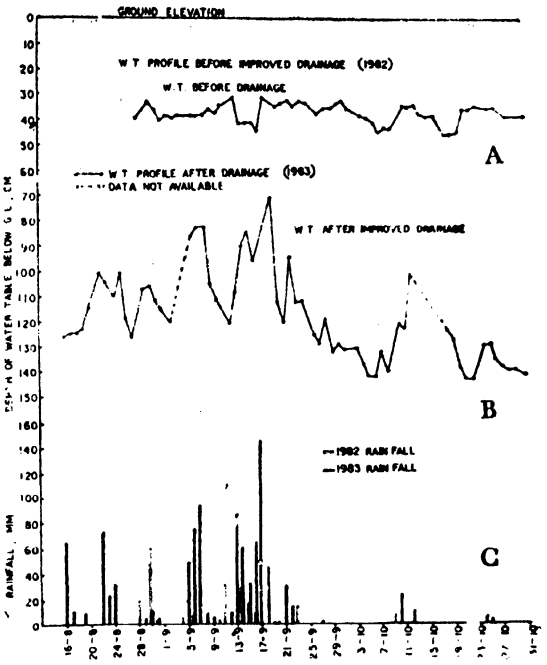


Fig 1. Water Table profile before Drainage (A) and after Drainage (B) in relation to rainfall in expt. area (Rungaroon T.E. Darjeeling)

has been installed to study the water table behaviour during rains. The water table was observed within 45 cm below ground level before drainage. The first phase of improved drainage system has successfully controlled the W.T. 75 cm below the ground level and has produced about 25% increase in crop as compared to last year.

Another experiment on open drainage system has been taken up in Kiran Chandra Tea Estate covering about 100 acres of land. The existing drainage system has not been adequate and failed to provide effective drainage. A large quantity of runoff water from forest area also enters the garden and floods the tea every year.

The project includes design of interception drain to cut off the runoff water coming from forest into the garden. An earthen embankment has also been raised to avoid flood water from entering the garden. Based on topographical survey data, the main drains have been designed and installed wherever required. A number of sub-main drains and lateral drains have been provided to drain soil excess water to control the water table 90 cm below ground level. The experiment is in progress.

C. DOOARS

(1) **Pump outlet**

An estate level research project has been taken up in Kalabari-Rangati Tea Estate to evaluate the design criteria for pump outlet. The project covers 111.03 ha of area. The major sources of excess water have

been identified as the seepage from high lands in north and spring water. A drainage system comprising of intereception drains, main drains, sub-main drains, lateral drains, sluice gates, reservoir and pumping plant has been designed based on soil, climate, topography and hydrological data collected from the area. A low head-high discharge pump of mixed-flow type has been designed to pump out 150 litres/sec. discharge (1,20,000 gph). Its power requirement has been only 12 H.P. This is the first time in tea industry that a mixed flow type of pump has been introduced for pumping out drainage water.

The data on water table, drain discharge and crop yield are presented in Figure 2.

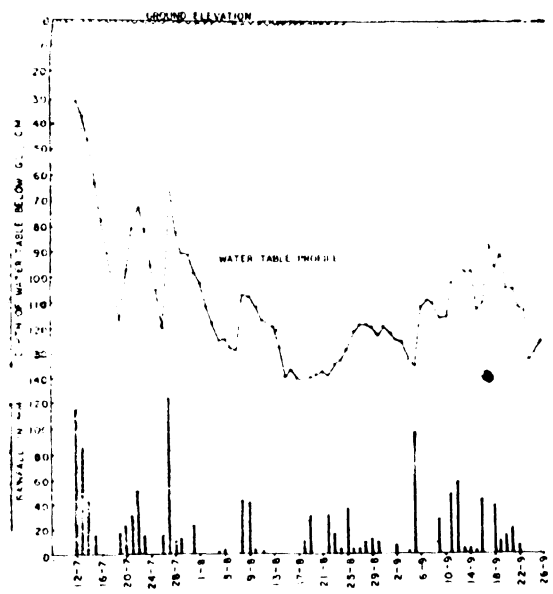


Fig 2. Water Table in relation to rainfall in Drained plot (Kalabari T.E. Dooars).

It can be seen clearly from figure 2 that the ground water table was successfully controlled, in general, about 90 cm below the ground level. There was a rise to water table above 90 cm level but only for a short period of time. Further improvement in drainage system is being brought to meet the requirement of the area based on the data collected so far.

Monthly crop yield data are shown in Table 1 for last two years. In 1982, improved drainage system produced on an average 20% increase in crop inspite of considerable reduction in NPK manuring, weedicide and pesticides and increased pruned area.

(2) Cement concrete home-made tiles

The cement concrete drain tiles have been fabricated in the water technology department of Nagrakata to replace very expensive PVC drain pipes - presently under use in T.R.A. experiments. The home made cement-concrete tiles are estimated to cost only Rs.

Table 1. *Statement on monthwise crop yield (made tea) during 1981 and 1982 in the experimental area*

Month	1981	1982	% Crop increase/decrease ( )
January	Nil	Nil	Nil
February	30.59	39.43	22.42
March	3003.82	4440.71	32.36
April	8712.51	12270.49	29.00
May	11509.50	17576.76	32.52
June	21227.67	19827.99	( )6.59
July	19500.40	23034.48	14.80
August	27855.13	37435.27	25.59
September	22307.34	33606.03	33.62
October	23162.68	24179.26	4.15
November	20118.97	22827.24	11.86
December	7130.93	19656.21	33.08
Total	164959.54	206163.83	19.99
Average yield	1444.73 kg/ha	1805.60 kg/ha	+360.90 kg/ha

Table 2. *Statement on NPK manuring and % prune during 1981 and 1982*

Year	% Area under LP + DS	N kg	P kg	K_2O kg
1981	41.62	13,827		7795
1982	58.40	10,917		5761

% increase in LP + DS area during 1982 — 16.82%
% decrease in N manuring during 1982 — 21%
% decrease in K_2O manuring during 1982 — 26%
Note : No 'P' application for more than 5 years.

10/— per metre as against Rs. 28/— and Rs. 60/— the cost of cement-asbestos pipes and PVC pipes respectively.

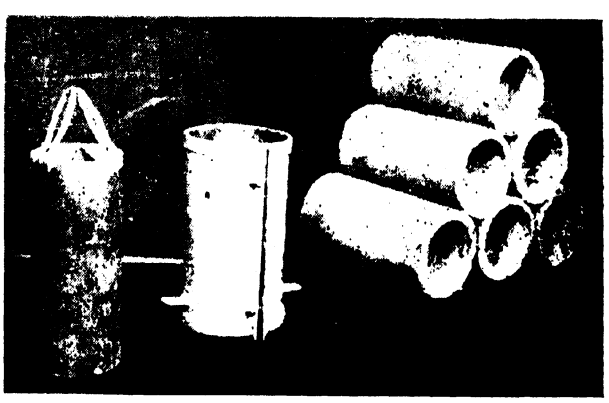


Plate 1. A set of moulds and Home made tiles developed at Nagrakata

The weight of each finished tile is 4.5 kg. It is 30 cm long and 12.5 cm (I.D.) and 16.10.(O.D.) with 1.8 cm wall thickness. A set of mould and home made cement concrete tiles are shown in plate 1.

About 400 such tiles have been installed in a plot ... testing their performance. Enough care has been ... in the design of tiles that they withstand load of ... and of vehicles moving on them without any damage ... they must have at least 75 cm soil cover on them. ... satisfactory test results of home-made concrete ... it may be possible to recommend their use in uns... soils. Plate 2 shows such an installation of home-... tiles in a field experiment in Dooars.

Plate 2. Installation of home made concrete tiles in an experiment in Dooars.

(3) Electronic water table meter

To overcome the practical problems and limitations of plopper, an electronic water table meter has been designed and developed at Water Technology Department Nagrakata. This meter operates on a small battery (D.C.) and measures the exact depth of water table by passing a low voltage D.C. power in any given situation. It is very small, light in weight and portable. This meter is estimated to cost about Rs. 100 and will last for a considerably larger period of time. Any semi-skilled labourer can use this instrument with great ease without making any mistake at garden level. It can be used in bent piezometers and can conveniently measure deep water tables very accurately. Plate 3 shows the recorder.

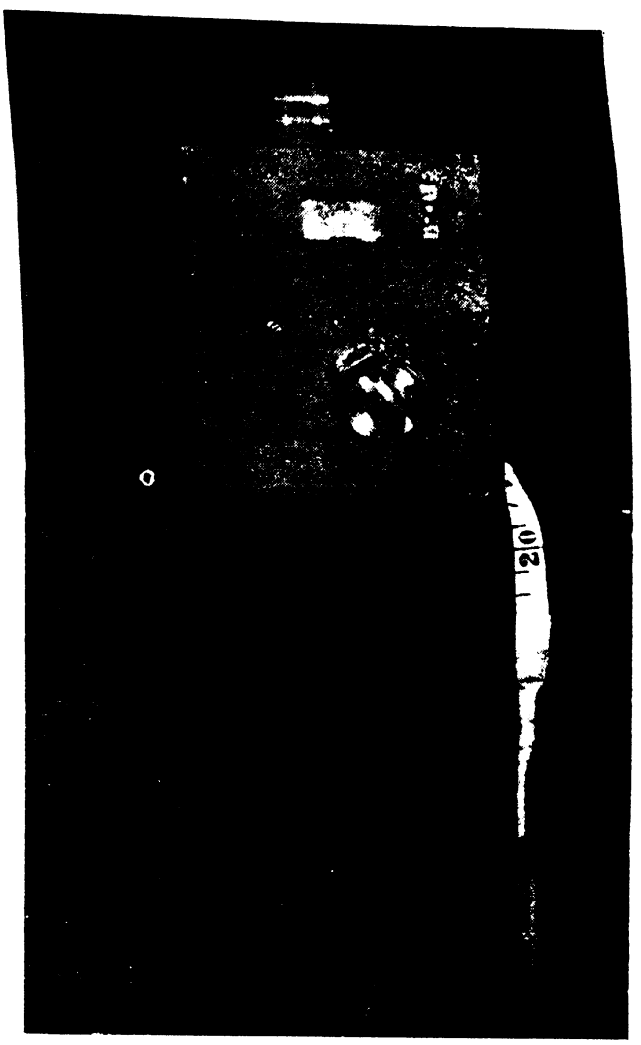


Plate 3. An electronic water table recorder developed at Water Technology Department Nagrakata.

PLANT BREEDING AND AGRONOMY

Highlights

1. *Two standard and one quality clones have been judged and are ready for release to the industry.*
2. *New clonal selection projects were taken in 7 estates. Under the scheme 221 promising mother bushes were selected during the year.*
3. *After completing initial trials 124 bushes out of 1095 selected earlier, were planted in long term trials.*

4. *Two new clones (one standard and one yield) are ready for release to the tea industry of Darjeeling during the year.*
5. *Twentyfive micro seed baris were established in 8 estates of Darjeeling to develop superior biclonal seed stocks.*
6. *Three valleywise clonal proving scheme were started in Darjeeling to select valley specific clones.*
7. *170 germplasm entries were planted in the* Camellia *gene sanctuary for their evaluation and preservation.*
8. *Initial growth of cuttings in subsoil upto 24" depth was found to be satisfactory.*
9. *The size of shoots at different spacing from 6944 plants/ha to 111111 plants/ha did not show any obvious differences.*
10. *The long term performance of TV clones 19,20,14,17, 16,1,8 and 18 was found to be better than others at TRA, Nagrakata.*

Plant Improvement

I. Collection, Evaluation and Preservation of tea germplasm

During the year, a total of 170 germplasm entries brought from different sources in the previous year, were planted in a long term field trial for their evaluation and long term preservation. An augmented Randomized Block Design has been adopted for the evaluation and preservation of germplasm. Rooting ability and initial observations have been recorded.

200 diverse genotypes selected in different tea estates of Dooars, Terai and Darjeeling were multiplied for their permanent establishment and evaluation in the Camellia gene sanctuary at Nagrakata.

II. Breeding of Clonal Varieties

(i) **Long Term Trials of clones at Nagrakata**—90 clones are in various stages of their field trials. Of these 50 clones were planted during 1981-83. The plants are coming up well and are expected to yield 5-7 good clones for droughty areas of Dooars, Terai and Goalpara.

Out of 39 entries planted in Quality Testing Trial, 2 standard and 1 quality clone have been judged and are ready for release to the industry. All the three are good rooters and have been found to establish well in the field. Furthermore, they are likely to do well in droughty areas of Dooars, Terai and Goalpara.

(ii) **Clonal Trials at CPS, Ging in Darjeeling** Out of 63 clones at various stages of long term trial at CPS, Ging more than 10 have been found promising as future clones. Two of the 7 trials planted in 1973 and 1974 have been completed and are under review. Out of 14 clones tried one standard and one yield clone are ready for release to the tea industry of Darjeeling. They are likely to do well under droughty conditions of Darjeeling.

(iii) **Valleywise Clonal Trials in Darjeeling**— Three trials consisting of 10-12 TRA approved clones could be planted in gardens representing 3 different valleys of Darjeeling. The plants are coming up well. Another 2 trials are expected to be established during the current year. Once these trials are completed, we may be able to give valleywise recommendations regarding suitability of planting materials.

(iv) **District Selection Scheme** Under the scheme, bush selection was taken up in the estates of Dooars, Terai, Darjeeling and Goalpara. A questionnaire about the aims and usefulness of the scheme was sent to all the member estates in the area. Over 70 estates replied and showed their willingness to initiate the scheme in their estates.

Table 1 sums up the current position of the scheme covering Dooars, Terai and Darjeeling. New selection of bushes in 7 estates of Dooars and Terai were taken, from which 221 mother bushes were selected.

Table 1. *Tea Estates surveyed and number of bushes selected in Dooars, Terai and Darjeeling upto 1982-83*

Particulars	Dooars	Terai	Darjeeling	Total
No. of estates surveyed				
1982-83	2	5	—	7
1975-82	15	5	5	25
Total area surveyed (ha).				
1982-83	15.12	33.1	—	48.22
1975-82	759.17	137.25	72	968.42
No. of bushes selected				
1982-83	77	144	—	221
1975-82	650	139	105	874
No. of long term trials established				
1982-83	9	5	1	15
1975-82	—	—	1	1
No. of clones in L.T.T.				
1982-83	80	34	10	124
1975-82	—	—	10	10

Till date 1016.64 hectares of old sections have been surveyed and 1095 mother bushes selected under the scheme.

During the year in addition to bush selection 15 long term trials were established where 124 clones were planted to evaluate their field and factory performance. Once the trials are completed at least 15-20 clones are expected to be approved. The selection team made 77 visits to the estates and 2 to CPS, Ging in Darjeeling to take up either follow-up measures for the previous schemes or to initiate new schemes.

A workshop of one day for the executives and staff of Duncans Agro Industries was arranged on clonal selection in tea estates. It was attended by about 50 people.

III. Breeding of Seed Varieties

(i) **Micro seedbaris in Darjeeling**—25 micro seedbaris representing a biclonal combinations of 12 approved clones were established in six different valleys of Darjeeling. Table 2 summarizes the establishment of micro-seedbaris. The baris are located at elevations of 500 to 1500 metres above the mean sea level.

Table 2. *Biclonal Micro seedbaris in Darjeeling*

Sub areas	Number of Micro seedbaris	Number of clones used	Year of planting
Darjeeling West	3	5	1982
Darjeeling East	3	5	1982
Darjeeling Central	16	14	1982
Rungbong	2	4	1982
Kurseong	3	5	1982
Mahanadi	4	5	1982
Total:	25	38	

The baris are expected to yield seeds for trials within 3-4 years time.

(ii) **Seed studies in Nanda Devi seedbari** - The study of flowering, fruiting, and seed development are in progress to find out the possible causes of low seed set and yield. Effect of drought seems to be one of the major causes of low seed set in the bari.

AGRONOMY

Long Term Clonal Trial

A long term clonal trial of Tocklai clones along with TS 203 started in 1967 was continued. Results are given in Table 3.

Table 3. *Yield of different clones at TRA, Nagrakata made tea (kg/ha)*

Clone	Average*	1981(Pr.)	1982(UP)
TV 1	3728	2999	4659
TV 4	2809	2277	2098
TV 7	2725	2378	1646
TV 8	3789	3829	4039
TV 9	3418	3431	3501
TV 10	3297	2819	3376
TV 11	3651	3110	4337
TV 12	3081	3118	3769
TV 14	4098	3737	4610
TV 16	3816	3896	4425
TV 17	3983	4170	4218
TS 203	2556	2318	2587

*Mean of one pruning cycle (Pr.- UP-DS-UP) from 1977-1980, spacing 4' × 3' (8970 bush/ha).

In the light pruned year of 1981, highest yield was obtained from clone TV 17 followed by TV 16, TV 8 and TV 14. TV 1 which was the best yielder in the unpruned year of 1982 which had remained far behind in the light pruned year of 1981. It appears that some clones perform better in the pruned year while others perform better in unpruned years(Table 3).

(ii) **New Long Term Clonal Trial**—A long term trial of Tocklai clones released after 1970 along with several experimental clones was planted in 1973 at TRA, Nagrakata. A summary of yield results are given in table 4. TV 19 yielded highest followed by TV 20, TV 17, TV 18 and TV 1 when averaged over a pruning cycle of four years (Pr.-UP-DS-UP). In the pruned year of 1979, Sundaram yielded highest followed by TV 19, TV 20 and TV 18. In the first unpruned year of 1980, TV 20 yielded highest followed by TV 19 and TV 17. In the deep skiffed year of 1981 the trend was not the same. TV 20 yielded highest followed by Sundaram and TV 1. In the final year of the cycle when bushes were unpruned for the second time TV1 gave highest crop followed by TV 17 and TV 19. It appears that clones behave differently in relation to the pruning operation (Table 4).

Table 4: *Yield of some recent released TV clones and Sundaram at TRA Nagrakata, made tea (kg/ha)*

Clone	1979 Pr	1980 UP	1981 DS	1982 UP	Mean*	Percent +over TV 1
TV 1	2581	3971	3039	3414	3259	0
TV 9	2336	2932	2777	2528	2643	-19.0
TV 17	2714	4412	2934	3412	3368	3.3
TV 18	2948	3943	2888	3280	3265	0.2
TV 19	3363	4499	3190	3345	3599	10.4
TV 20	3240	4503	3522	2838	3551	9.0
TS 203	1993	2649	2254	1904	2200	-32.5
Sundaram (B.5.63)	3414	3685	3460	2585	3286	0.8

*Mean of one pruning cycle (Pr.-UP-DS-UP), spacing 3'×2' (13,605 bush/ha)

(iii) **Long term trial of Tocklai released biclonal stocks**—A long term trial of Tocklai released biclonal stocks was planted in 1974 at TRA, Nagrakata. A summary of yield results are given in Table 5. In a year of prune TS 462 outyielded the rest followed by TS 464. When it was kept unpruned, the same stocks were on the top in the same sequence. The trend was changed in the year of deep skiff when TS 449 yielded highest followed by TS 464 and TV 1. It appears that the different stocks behave differently in relation to pruning. Over the years TS 462 yielded 8.5% higher than TS 449 control. In comparison to TV 1, TS 462 and TS 464 yielded 9.2% and 8.8% higher respectively.

Table 5. *Yield of Tocklai released biclonal stocks at TRA, Nagrakata, made tea (kg/ha)*

Stocks	1980	1981	1982	Mean*	% +over TS 449
TS 449	3556	3296	3099	3317	0
TS 378	3079	3170	2646	2965	-10.6
TS 462	3844	3904	3051	3600	8.5
TS 463	3667	3464	3010	3380	2.0
TS 464	3832	3871	3065	3589	8.2
TV 1	3469	3375	3050	3298	- 0.6

*Average of 3 years (1980 to 1982), spacing 3½' × 2½' (13,605 bush/ha)

(iv) **Vegetative propagation**— An experiment was initiated on the possibility of using sub-soil for the propagation of tea cuttings in 1982-83. The growth of cuttings in the soils taken from the depth of 15 cm to 60 cm below the ground is being studied. Callusing

and initial rooting of cuttings in all the treatments have been found satisfactory. However, further observations are awaited.

(v) **Plant spacing**—A systematic fan design experiment was planted in September/October 1977 with TV 1 clone at 22 different spacings ranging from 30 cm to 120 cm (giving 6944 plants/ha to 111,111 plants/ha). The same experiment was initiated earlier in July 1974 at Tocklai. The results of this experiment were reported in Ann. Sci. Repts. from 1976-77 to 1979-80.

Besides the yield recording, attempts were made to study the effect of plant growth parameters at TRA, Nagrakata in 1982-83. A summary of results is given in Table 6. The closer spacing reduced the plucking surface, collar diameter, number of pruning sticks per bush and weight of pruning litters per bush. However, closer spacings increased the mortality of bushes considerably above 26015 plants/ha. Density of plucking points and size of pluckable shoots was not affected by closer spacing.

The effect of plant density on yield is summarized in Table 7. The results show that yield increased with increase in population upto 4th year after planting. In 5th year after planting, beyond 11,790 plants/ha over the 3rd year it started declining. The closer spacing did

Table 6. *Effect of plant density on growth and development in tea*

Spacing cm	Stand density per ha (apprx)	Length* 21 + b mm	Dry wt. 21 + b mg	No. pluckable points per 100sq of bush surface	Bush diameter of the pluckable surface cm	Collar diameter, cm	No. pruning sticks/bush	Wt.of pruning litters/bush gm	Mortality after 6 years of planting%
30.0	111,111	56	14	9	34	26	5	220	18
32.0	97,656	54	12	12	32	28	4	370	22
34.2	85,470	55	14	10	37	33	5	350	27
36.6	74,627	55	12	12	35	32	6	370	20
39.1	65,402	57	14	11	42	34	5	400	27
41.7	57,504	55	14	12	46	38	7	380	24
44.6	50,277	53	12	12	44	36	8	400	33
47.6	44,131	57	14	13	44	38	8	540	14
50.9	38,595	57	14	13	46	41	7	430	22
54.3	33 921	59	12	15	51	41	9	580	10
58.0	29,727	56	12	15	57	44	10	720	16
62.0	26,015	56	12	16	58	42	11	800	6
66.2	22,821	57	12	15	62	52	12	1340	4
70.7	20,008	57	12	14	68	51	14	1280	4
75.6	17,498	56	12	13	67	53	16	1200	4
80.7	15,356	58	12	13	74	53	15	1450	4
86.?	13,459	58	14	13	79	52	14	1160	4
92.1	11,790	58	14	13	82	64	15	1620	Nil
98.4	10,327	56	14	11	85	61	17	1660	Nil
105.1	9,053	59	14	13	95	65	16	2100	2
112.3	7,930	59	12	14	100	64	19	2200	2
120.0	6,944	58	12	14	100	69	21	2710	2

*Mean of 30 occasions from July to October, 1982

Table 7. *Yield of made tea (kg/ha) and green leaf per bush (kg) at different populations in tea at TRA, Nagrakata*

Plant populations per ha (apprx)	Made tea kg/ha			Percent + over 6,944 plants per ha 1982	Green leaf bush, kg		
	1980 UP	1981 DS	1982 UP		1980 UP	1981 DS	1982 UP
111,111	5375	4675	2375	2.2	.215	.187	.095
97,656	5164	3670	2351	1.2	.235	.167	.107
85,470	5692	4423	2577	10.9	.295	.230	.134
74,627	5306	3879	2317	-0.3	.316	.231	.138
65,402	5621	5254	2767	19.1	.382	.357	.188
57,504	4360	4270	2665	14.7	.337	.330	.206
50,277	4491	4310	3631	56.3	.397	.381	.321
44,131	4716	3892	2810	21.0	.475	.392	.283
38,595	4047	3387	2648	14.0	.466	.390	.305
33,921	4221	3427	2488	7.10	.553	.449	.326
29,727	3912	2869	2542	9.4	.570	.429	.380
26,015	3571	2798	2693	16.0	.610	.478	.460
22,821	3641	2377	2932	26.2	.709	.463	.571
20,008	3444	2255	2467	6.2	.765	.501	.548
17,498	3110	2169	2441	5.1	.790	.551	.620
15,356	2847	2194	2505	7.8	.824	.635	.725
13,459	2617	1820	2438	5.0	.854	.601	.805
11,790	2541	1937	2719	17.0	.954	.730	1.025
10,327	2324	1617	2410	3.7	1.000	.696	1.037
9,053	2318	1573	2448	4.5	1.138	.772	1.201
7,930	2009	1485	2193	-5.6	1.126	.832	1.229
6,944	1847	1387	2323	0.0	1.182	.888	1.487

Year of planting, 1977

not give higher yields per hectare beyond certain populations due to lower yields per bush under those populations. Results indicate that plant populations between 12,000 to 15,000 plants/ha may be optimum for sustained productivity in tea.

Appendix A

List of visits made to various places by Dr. I.D. Singh during 1982-83.

- Jalpaiguri on 6th/7th May to attend Centenary Celebration and Seminar on Tea of Gurjangjhora Tea Co. Ltd.
- Darjeeling on 4th April to attend ASC, meeting and Bengdubi club, Terai on 7th October to attend district seminar.

Appendix—B

List of experiments conducted in the member estates by the Department of Plant Breeding and Agronomy of TRA, Nagrakata.

(i) List of estates under District Selection Scheme in Plant Breeding and Agronomy Department, TRA, Nagrakata on 31.3.83.

(a) Dooars :	(1) Bantgoorie	(2) Sam Sing	
	(3) Birpara	(4) Hantapara	
	(5) Garganda	(6) Leesh River	
	(7) Ghatia	(8) Turturi	
	(9) Rydak	(10) Chuapara	
	(11) Joybirpara	(12) Central Dooars	
	(13) Makrapara	(14) Binnaguri	
	(15) Huldibari	(16) Engo	
	(17) Jaldacca Altadanga	(18) Nagrakata	
	(19) Bhogotpore		
(b) Terai :	(20) Sannyasithan	(21) Kamalpur	
	(22) Panighatta	(23) Azamabad	
	(24) New Chumta	(25) Sukna	
	(26) Mohurgong & Gulma		
	(27) Sahabad	(28) Nuxalbari	
	(29) Tirrihann		
(c) Darjeeling:	(30) Lingia	(31) Soom	
	(32) Happy Valley	(33) Goomtee	
	(34) Singbulli	(35) Longview	

(ii) List of experiments other than clonal selection:

Sl. No.	Experiment	Site	Year of starting
1.	Rehabilitation of uprooted tea soils	Longview T.E.	1982
2.	Valleywise clonal Proving Scheme	Thurbo, Soom, Longview	1982
3.	Micro seed bari	Thurbo, Soom, Lingia, Happy Valley, Singtam, Goomtee, Longview, Tukdah	1982
4.	Genotype × environmental interaction	Dooars	1982

Appendix—C

List of publications

1. Singh, I.D. 1982. Planting materials for today and tomorrow. In Souvenir Gurjangjhora Tea & Industries Ltd. Centenary Celebrations, Jalpaiguri, May 7-8, 1982.

(Abs. The significance of developing locally adopted planting materials according to the needs of the region has been highlighted. The various efforts being made by TRA to evolve such planting materials for Dooars, Terai, Darjeeling and Goalpara are focussed. Besides tea, the need of planting materials of ancillary plant like shade, firewood, fencing posts, rehabilitation etc. for the tea estates of the region are briefly highlighted).

2. Khadi, B.M. and Singh, I.D. 1982. Correlation among economically important characters in papaya. Pantnagar J. Res : 6(1)

(Abs. Phenotypic, genotypic and environmental correlations among characteristics in papaya were studied. Phenotypic correlations coefficients of fruit yield with number of fruits/plant, fruit volume and weight, fruiting length, fruit size, plant height, leaf area/plant, and dry weight of seed fruit were positive and significant. Generally phenotypic correlations were higher than genotypic correlations. Some positive and significant environmental correlations like fruit yield/plant with no. of fruits/plant, weight/fruit with width of the fruit etc. were found).

ENTOMOLOGY

I. Sucking Insect : Thrips

Six Tocklai-released clones TV1, TV9, TV17, TV18 to TV20 and Stock 203 were evaluated for their susceptibilities to thrips during the peak period of the abundance of the pest, i.e. April-June. On the basis of percentage of damaged shoots, these clones varied in their susceptibility to thrips. The scale of susceptibility (Table 1) is TV1 > TV18 > TV17 > TV9 > Stock 203 > TV19 > TV20.

Table 1: *Clonal susceptibility of Thrips (% of shoots damaged)*

Months	TV1	TV9	TV18	TV17	TV19	TV20	Stock 203
April	7.46	5.43	7.19	5.83	3.46	3.26	4.78
May	6.83	3.84	6.48	4.78	3.12	3.18	3.46
June	5.11	3.16	5.26	3.54	2.32	2.16	3.00

To study the effectiveness of Nuvacron, Ekalux EC 25, Dimecron, Thiodan 35 EC and Hildan 35 EC on thrips, a field trial was carried out using a high volume sprayer. Nuvacron (@ 36 ml a.i./ha), Ekalux (@ 200 ml a.i./ha), Thiodan and Hildan (@ 280 ml a.i./ha) gave more than 90% reduction of thrips population upto seven days.

Scale insect

A scale insect, *Hemiberlesia repax* (Comstock) has caused considerable damage to tea in many gardens

in Darjeeling. The petioles of the leaves were the primary sites of infestation, and severe infestation caused defoliation of mature bushes. The peak period of incidence was June to August.

II. Cockchafer

Three Tocklai clones TV1, TV9 and TV18 were examined during April to August to evaluate their susceptibility or otherwise resistance to cockchafer. Each clone had three replicated plots, each plot with 30 bushes. The results (Table 2) show that TV1 is most susceptible and TV 18 is the least, though this needs further confirmatory studies.

Table 2. *Clonal susceptibility to cockchafer damage.* (*Degree of attack*)

Clones	April	May	June	July	August
TV 1	0.13	0.36	0.71	1.20	1.43
TV 9	0.20	0.46	0.76	1.33	1.40
TV 18	0.10	0.30	0.56	0.76	0.93

Three sets of field trials were conducted during May-July to see the mortality of adult cockchafer beetles at the time of aggregation. Decis 2.8 EC, Permethrin 10 EC and Sumicidin 20 EC at 1 : 2000 and Thiodan 35 EC and Ekalux EC 25 at 1 : 200 were sprayed on the beetles with a low volume sprayer. 72 hours after spraying, a 90— 93% mortality was obtained with all the insecticides except Sumicidin which gave 88% kill.

III. Defoliator : Red slug caterpillar

Dimethoate was tested against red slug at 1 : 200 dilution with a power sprayer. Thiodan at same dilution was used as a standard.

Dimethoate (Tara 909) gave 82% reduction of population after 72 hours, Thiodan gave 90% kill.

In another trial, Decis 2.8 EC, Sumicidin 20 EC, Cymbush 25% EC and Pay off AC 222705 (a synthetic pyrethroid) were applied against red slug. The chemicals were sprayed at 1 : 4000 with a low volume sprayer.

48 hours after treatment, a 99—100% mortality of the pest was obtained with all the insecticides.

IV. Termite

An experiment with some granular insecticides was carried out to control termite infestation on mature tea. The infestation was indexed using a scale : 0 = no infestation, 1 = slight, 2 = moderate, 3 = severe and 4 = very severe infestation, once before and 6 and 12 months after insecticidal application.

Table 3. *Effect of granular insecticides on termite*

Treatment	Degree of attack/bush before treatment	Post-treatment observation			
		6 months		12 months	
		Degree of attack	%reduction over control	Degree of attack	% reduction over control
Furadan 3G (@ 5g/plant	1.80	0.89	33.08	0.42	70.42
Furadan 3 G (@10 g/plant	1.57	0.42	68.42	0.26	81.69
Thimet 10G @ 5g/plant	1.37	0.62	53.38	0.54	61.77
Thimet 10G (@ 10 g/plant	1.30	0.38	71.43	0.24	83.09
Ekalux 5G (@ 5 g/plant	1.43	0.76	42.86	0.48	66.20
Ekalux 5 G (@ 10 g/plant	1.47	0.62	53.38	0.36	74.65
Control	1.27	1.33	—	1.42	—

The summarised results (Table 3) show that Furadan and Thimet at 10g/plant gave good control of termite infesting tea. These studies are being continued to establish long-term effects of these granular pesticides in controlling termite.

V. Advisory Services

Soil analysis

Over 960 samples of soils analysed for eelworms. About 9% of the soils had eelworm population higher than the critical level.

Bioassay of Pesticides

46 sample of pesticides received from member gardens in Dooars, Terai and Darjeeling were bioassayed in the laboratory.

Pest/disease identification: General comment

56 samples of pest/disease damaged materials were identified and appropriate control measures were suggested.

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY ADVISORY DEPARTMENT 1982/83

Project	Site	Index No.	Year of Starting
SOUTH BANK			
NPK manuring of mature tea	Panitola	AS 108	1973
NPK manuring of mature tea	Thowra	AS 111	1973
NPK manuring of mature tea	Rupai	AS 114	1973
NPK manuring of mature tea	Diffloo	AS 120	1973
NPK manuring of mature tea	Meleng	AS 142	1976
Rejuvenation experiment	Tara	AS 128	1974
Rejuvenation experiment	Dilli	AS 160	1978
Young tea manuring (YTD)	Fatikjan	AS 144	1976
Young tea manuring (YTD)	Meleng	AS 145	1977
Young tea manuring (Response surface-NPK)	Balijan N	AS 153	1979
New plucking round	Nahortolli	AS 170, AS 171	1979
Times of pruning/skiffing	Daimukhia	AS 173	1980
Times of pruning/skiffing	Daimukhia	AS 174	1980
Times of pruning/skiffing	Daimukhia	AS 175	1980
Times of pruning/skiffing	Hatikhuli	AS 176	1980
Times of pruning/skiffing	Hatikhuli	AS 177	1980
Times of pruning/skiffing	Hatikhuli	AS 178	-do-
Micronutrient trial	Cinnamara	AS 185	1980
Look see trial	Sepon	AS 188	1982
Bringing up of young tea	Sealkotee	AS 189	1981
Cessation & reduction of N	Besacopie	AS 192	1982
	Ducklingia	190	"
	Tyroon	191	"
NORTH-BANK			
NPK manuring of mature tea	Monabarrie	AN 116	1973
NPK manuring of mature tea	Nahorani	AN 123	1973
Nitrogen with and without mulch	Sessa	AN 138	1975
Spacing trial	North-Bank	AN 152	1977
Biclonal seed trial	N.B., H.Q.	AN 172	1979
Long term agricultural trial	HQ	AN 179	1980
Times of pruning/skiffing	Dekarai	AN 180	1980
	Dekorai	AN 181	1980
	Dhekiajulie	AN 182	1980
	Dhekiajulie	AN 183	1980
	Dhekiajulie	AN 184	1980
Bringing up of young tea	N.B., H.Q.	AN 186	1981
Biclonal Stock trial	H.Q.	AN 187	1981
Cessation & Reduction of N	Addabari	AN 193	1982
CACHAR			
Rejuvenation Experiment	Isaabheel	C 47	1974
Young tea manuring (YTD)	Barjallingah	C 49	1977
Young tea manuring (Response surface-NPK)	Arcuttipore	C 50	1977
Bringing up of young tea (Studies on frame development)	Arcuttipore	C 51	1977
NPK manuring of mature tea	Longai	C 39	1973
NPK manuring of mature tea	Silcoorie	C 38	1973
Spacing trial	Borjallingah	C 55	1977
Times of pruning/skiffing	Arcuttipore	C 58	1980
	Arcuttipore	C 59	1980
	Arcuttipore	C 60	1980
	Derby	C 61	1980
	Derby	C 62	1980
	Derby	C 63	1980
Cessation & reduction of N	West Jallinga	C 64	1982
DOOARS & TERAI (WEST BENGAL)			
NPK manuring of mature tea	Bagrakote	D 55	1973
NPK manuring of mature tea	Samsing	D 56	1973
NPK manuring of mature tea	Nimtijhora	D 57	1973
NPK manuring of mature tea	Gangaram	TR 7	1973
Shade in relation to level of tea nutrition	Satali	D 78	1978
Rejuvenation Experiment	Dalgoan	D 43	1972
	Matalli	D 44	1972
	Kumtai	D 47	1972
	Gangaram	TR 5	1972
Long term trial	Nagrakata HQ	D 61	1974
New long term trial	Nagrakata HQ	D 62	1975
Young tea manuring (YTD)	Nagrakata HQ	D 65	1975
Young tea manuring (Response surface-NPK)	Nagaisurrie	D 66	1977
—do—	Lokhipara	D 68	1977
Spacing trial	Bogatpore	D 69	1978
Times of pruning/skiffing	Nagrakata HQ	D 77	1977
	Boradighi	D 83	1980
	Boradighi	D 84	1980
	Boradighi	D 85	1980
Cessation & Reduction of N	Gandrapara 3yr	D 92	1982
	" 4yr	D 93	"
	Hansqua 3yr	TR 94	"
	4yr	TR 95	"
DARJEELING			
NPK manuring of mature tea	Chongtong	DJ 34	1973
—do—	Nagraifarm	DJ 35	1973
Young tea manuring (YTD)	Gaille	DJ 48	1978
Young tea manuring (Response surface-NPK)	Phoobsering	DJ 47	1978
Times of pruning/skiffing	Teestavalley	DJ 49	1980
	Salimbong	DJ 50	1980
	Salimbong	DJ 51	1980

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY OTHER DEPARTMENTS

PLANT PROTECTION DEPARTMENT (ENTOMOLOGY)

Sl. No.	Experiment	Location	Site	Year of Starting
1.	Looper control experiment	South Bank	Gabroo Purbat	1982
2.	Jassid control experiment	South Bank	Kharikatia	1983
3.	Effect of granular pesticides on red spider	South Bank	Cinnamara	1983
4.	Spraying technique	South Bank	Lohapohia	1982
5.	Red spider control trial	South Bank	Cinnamara	1982
6.	—do—	South Bank	"	1983

PLANT PROTECTION DEPARTMENT (MYCOLOGY)

Sl. No.	Experiment	Location	Site	Index No.	Year of Starting
1.	Evaluation of different formulations against red rust	South Bank	Sangsua	MR·034	1982
2.	Screening of fungicides	South Bank	Kharikatia	MB 027	1982
	against black rot	South Bank	Kakajan	MB 028	1982
3.	Black rot sclerotial	South Bank	Tyroon	MB 029	1982
	suppression by fungicide	South Bank	Bukhial	MB 030	1982
4.	Effect of biofertiliser on yield	South Bank	Rajah Alli	MF 001	1982

TEA TASTING DEPARTMENT

1.	Karangani T. E.	—	Colour of C.T.C.
3.	Duklingia T. E.	—	Drying curve on C.T.C. tea
3.	Heeleakah T. E.	—	Tea Breaker cum Stalk Separator
4.	Koomber T. E.	—	C.T.C. Experiment
5.	Bhubandar T. E.	—	—Do—
6.	Jutlibari T. E.	—	Orthodox Experiment
7.	Arcutipur T. E.	—	C. T. C. Experiment
8.	Rungli-Rungliot	—	Darjeeling C.T.C. tea during rains
9.	Pandam T.E.	—	—Do—

ESTATES UNDER CLONAL SELECTION SCHEME IN BOTANY DEPARTMENT IN 1982-83

(a) **ASSAM-NORTH BANK** 19 Estates	(1) Borengajuli	(2) Choibari	(3) Cinnatolliah	(4) Dhunseri	(5) Dufflaghur
	(6) Dhullie	(7) Dimakusi	(8) Bormahjan	(9) Doolahat	(10) Hattigor
	(11) Moroni	(12) Monabarie	(13) Majuli	(14) Nagrijuli	(15) Nonaipara
	(16) Orang	(17) Orangjuli	(18) Seajuli	(19) Tarajuli.	
(b) **ASSAM-SOUTH BANK** 39 Estates	(1) Amlukie	(2) Bukhial	(3) Borsillah	(4) Borban	(5) Barpathar
	(6) Borahi	(7) Balijan North	(8) Charaideo Purbat	(9) Dehingeapar	(10) Dilli
	(11) Dinjan			(12) Dooria	(13) Dejoo Valley
	(14) Deepling	(15) Dalowjan	(16) Dhoedaam	(17) Deohall	(18) Dinjoye
	(19) Dirok	(20) Digulturrung	(21) Gabroo	(22) Gatoonga	(23) Gopal Krishna
	(24) Heeleakah	(25) Joonktollee Purbat		(26) Kaliapani	
	(27) Koomsong	(28) Lengree	(29) Limbururi	(30) Ledo	(31) Mukrong
	(32) Monabari	(33) Maijan	(34) Negheriting	(35) Namburnadi	(36) Sungsua
	(37) Tingalibum	(38) Teloijan	(39) Thowra.		
(c) **CACHAR** - 7 Estates	(1) Borojalinga	(2) Burnie	(3) Chandighat	(4) Longai	(5) Lallamokh
	(6) Narsingpore	Braes	(7) Poloi.		
(d) **TRIPURA** - 3 Estates	(1) Huplongcherra	(2) Harendranagar	(3) Maghlibundh.		
(e) Heeleakah T. E.	} Young tea management using growth regulators.				
Scalkotee T. E.	}				
Meleng T. E.	| Crop regulation using growth regulators.				

STATISTICS DEPARTMENT

Sl. No.	Project	Site (T. E.)	Index No.	Year Started
1.	Uniformity Trial	Nagri Farm (Darjeeling West Bengal)	—	1964

Appendix - C

Banerjee, B : An analysis of the effect of latitude, age and area on the number of arthropod pest species of tea. *Journal of Applied Ecology*, 18, 339-342.

Abstract : An analysis of the arthropod pest complex on tea from fourteen geographic locations shows that the numbers of pest depend on the length of time during which tea has been grown in an area. The area under tea becomes important only after allowing for age effect. Latitude has no effect. Tea pests reach a saturation level when bushes are about 35 years old: the level of saturation presumably depends on the richness of the arthropod species attacking tea.

Banerjee, B : A strategy for the control of *Andraca bipunctata* Walker on tea. *Crop Protection* (1982) 1(1), 115-119

Abstract : Larvae of *Andraca bipunctata* Walker (Bombycidae: Lepidoptera) rapidly defoliate mature tea plants in northeast India, necessitating the application of insecticides that will kill or knock them down quickly. In a field trial in 1978, the synthetic pyrethroids permethrin and deltamethrin both gave excellent control of this defoliator at 0.5 g/ha, although the effect was more persistent at 1.0 g/ha. These insecticides failed to reach the target sites within dense canopies and treatments were less effective during periods of heavy rainfall. The tachinid parasite *Cylindromya sp.* became active, although it failed to keep the number of larvae below the damaging level.

Banerjee, B : Size-classes of workers and their distribution in the mounds of *Odontotermes redemanni* (Wasmann) (Isoptera : Termitidae), *Proceedings of the Zoological Society*, 32: 121-126.

Abstract: On the basis of their body lengths, the workers of *Odontotermes redemanni* (Wasmann) may be grouped as minor (log 0.48-log 0.53 cm), medium (log 0.57-0.60 cm) and major (log 0.63-log 0.65 cm) workers. In the early stage of mound-growth production of minor workers is high ; in the intermediate phase there is a preponderance of major workers in the population. At optimal stage of mound growth, size-distribution follows a near normal distribution, with the medium workers forming the bulk of the worker population. It is speculated that size-distribution of the workers is related to the functional needs of the colony.

Srivastava, R. A. K., Mathur, S. N. and Dev Choudhury, M. N. (1982). Pysiological aspects of different levels of nitrogen utilization in *Camellia sinensis* L. with respect to yield and quality of made teas. *Indian Journal of Experimental Biology* 20, pp 152-155.

Abstract: Nitrogen utilization by *C. sinensis* based on enzyme response in terms of biosynthesis of organic compounds which are related to the quality of made tea was studied in 3 plots of Tocklai released clone TV-1 exposed to 3 different levels of nitrogen. Carbohydrate decreased with increased nitrogen utilization. At higher nitrogen levels (300 kg/ha) nitrogenous substances (protein, caffeine and amino acids) decreased compared to nitrogen exposure at 200 kg/ha indicating repression of enzymes involved in the biosynthesis of these compounds, whereas polyphenols remained almost unaltered with varied doses of nitrogen exposure. Glutamine, arginine and theanine showed appreciable degree of fluctuation and seemed to be involved in enzyme repression. Both the yield as well as quality of made teas were found to be favourable at 200 kg/ha nitrogen exposure.

Mahanta, P. K. 1982. Japanese Tea Research Institutes. *'The Planters' Chronicle'* June 1982, pp 153-155. Republished *Cha-Ki-Bat* Vol. XXVII, 41 1489-1494.

Abstract: In view of its fully mechanised cultivation and manufacture, and supported by a strong Research & Development set-up, the Japanese tea industry holds itself out on the global tea habitation. There are a number of individual characteristics which may have a bearing on the Indian scenario. Dr. P. K. Mahanta, who recently undertook a study tour to the Japanese tea pockets and institutes, attempts to highlight these in this report.

Takeo, T. and Mahanta, P. K. 1983. Comparison of Black Tea aromas of Orthodox and CTC tea and of Black Teas made from different varieties. *J. Sci. Food Agric.* 34 pp. 307-310.

Abstract: Volatile compounds obtained from orthodox black tea and CTC tea were analysed by a g.c.-m.s. method. A difference in the contents of cis-3-hexenol, linalool, linalool oxides, methylsalcylate and geraniol was found between the two types of tea. It was thought that the difference in the con-

tents of volatile compounds might be produced by the individual manufacturing processes. A typical difference in the contents of linalool and geraniol was observed in volatile oils of black teas made from cultivars of *v. assamica* and hybrids of *assamica* and *sinensis*. The difference in the volatile compounds in black teas may be related to the genetic variation.

Hazarika, M. and Mahanta, P. K. 1983. Some studies on Carotenoids and their degradation in Black-Tea Manufacture. *J. Sci. Food Agric.* 34 pp. 1390-1396.

The four major carotenoids, β-carotene, lutein violaxanthine and neoxanthine were estimated spectroscopically in four different Tocklai Experimental Station released tea clones, namely, TV-1 (China hybrid), TV-2 (Assam (Betjan) variety), TV-9 (Assam-Cambod variety) and TV-17 (China hybrid). The quantitative changes of these carotenoids in different stages of black-tea manufacture were also studied in TV-2 (less flavoury) and TV-17 (flavoury) clones against TV-1 as standard. Comparative study showed that TV-2 contained the least amount of these carotenoids whereas TV-9 and TV-17 contained greater amounts. All these carotenoids were found to decrease appreciably during black-tea manufacture. The decrease was found to be higher in the curling, tearing, crushing method than in the conventional orthodox method of tea manufacture. The changes of two of these carotenoids viz. β-carotene and lutein were not significant statistically during withering but were highly significant during fermentation. However, the reverse was true for violaxanthine where as the neoxanthine shows significant changes in both of these stages. The vitamin-A value was calculated from residual β-carotene amount, the provitamin A, in black tea.

Hazarika, M. and Mahanta, P. K. 1984. Compositional changes in Chlorophylls and Carotenoids during the four Flushes of Tea in North East India.

J. Sci. Food Agric. 1984, 35 pp. 298-303

Abstract: The quantitative changes of two pigments, chlorophylls a and b, and four major carotenoids, β-carotene, lutein, violaxanthine and neoxanthine, were investigated during four flushes of North East Indian plain teas from a deep skiffed area between April and October 1982. The tea flushes with different genetic properties were taken from various Tocklai-released clones: TV-1 (*Camellia sinensis* (L.) O.Kuntze), TV-2 (*C. assamica* (Masters) Wight), TV-9 (*C. assamica* 'Cambod') and TV-17 (*C. sinensis*, hybrid). They showed marked changes in these pigment constituents throughout the plucking period, which affected the organoleptic 'property of the black tea produced.

Deb. D. L., Sen, A., Rattan, R. K., Meisheri, M. B., Gupta, G. N. and Sharma, K. N. 1983. Diffusion of Zinc as influenced by physical and chemical properties of soils. *Z. Pflanzenernaehr. Bodenk.* 146, pp. 494-503. Presented in 12th International Congress of Soil Science New Delhi, 8-16 February 1982.

Abstract: The self diffusion coefficients of zinc (DaZn), determined by half cell technique, were found to be greatly influenced by variations in soil characteristics such as volumetric moisture content, bulk density, temperature, carrier zinc concentration and soil pH. The DaZn values showed exponential decrease with increase in soil pH but with increasing volumetric moisture content, DaZn values showed logarithimic increase. The highest DaZn value was obtained at a compaction of 1.50 g/cm^3. Increase in temperature from 5° to 30°C showed 4 to 20 times increase in DaZn values. An attempt was made to study the relationship between soil characteristics and DaZn values for 87 illitic soils differing in physical and chemical properties. The simple and multiple correlation coefficients did not account for more than 21 per cent of variations indicating that DaZn values cannot be predicted accurately from soil properties.

Chamuah, G.S. and Dey, S.K. 1982 Cation-Exchange Capacity of Clonal Tea Roots and its Implications on Fertiliser Responses.

J. Sci. Food Agric. 33, pp. 309-317

Abstract: Fifteen genetically different tea clones showed no variation in their root cation-exchange capacity (CEC) values when assessment was made separately on white (including creamy white and cream) and brown (including creamy brown and reddish brown) portions of roots. But CEC values determined on the whole root system of the same clones were significantly different. This was true for plants varying in age from 8 to 18 months. Clones of Assam types gave lower root CEC values throughout the experimental period than China types, while clones of the southern form of tea (Cambod) gave high root CEC values initially, which dropped rapidly as the plants became older. Root CEC of different clones was found to be negatively correlated with the brown : white root ratio and with the

K : $\sqrt{Ca}$ ratio of the plant tops. Ageing of plants decreased root CEC by increasing the porportion of brown roots, as a result of which the K:$\sqrt{Ca}$ ratio also decreased with age.

Nath, A. K. and Dey S. K. 1982. studies on potassium releasing pattern in various textural types of alluvial soils of Assam by the method of exhaustive cropping. *J. Indian Soc. Soil Sci.* 30(3) pp. 291-295.

Abstract: The Potassium intensity values of three alluvial soils under exhaustive cropping with rye grass (Lolium perenne) decreased progressively during the initial cropping period, when dry matter yield, K uptake and K concentration in harvested material increased. Thereafter, the intensity values tended to increase to their original levels for a period when dry matter yield, K uptake and K concentration of harvests decreased gradually. During the later cropping period, these parameters declined slightly until soils reached exhaustion levels. The intensity values at the exhaustion levels were found to be nearly same for all the three soils. K intensity values were not significantly correlated with dry matter yield. The estimated uptake of nonexchangeable potassium during exhaustive cropping varied between 0.90 to 2.74 mg K/100 g soil, the lowest and highest uptake coinciding with the shortest and longest periods at which exhaustion signs were exhibited.

Chamua, G. S. and Dey, S. K. 1982. Note on the effects of different levels of calcium and potassium on clonal tea plants. *Indian J. agric.Sci.* Vol. 52 No. 4 pp. 257-259.

Chamua, G. S. and Dey, S. K. 1982. Determination of cation exchange capacity of woody plant roots. *Plant and Soil*, Netherlands, 68, pp. 135-138.

Goswami, P. C., Ghosh, P. and Dey, S. K. 1983. Studies on design storms in the tea areas of North-East India. *Agri. Engineering Today* (in press).

Chamua, G. S. and Dey, S. K. 1983. Effect of growth regulators on cation exchange capacity of tea roots. *Plant and Soil*, Netherlands, (in press).

Chamua, G. S. and Dey, S. K. 1983. Effect of nitrogen fertilizers on root growth and nutrient uptake of young tea plants. *J. Hort. Sci.* (in press).

Chamua, G. S. and Dey, S.K. 1983. Influence of nitrogen fertilisers on root cation exchange capacity of clonal tea plants. *Indian J. Agric. Sci.* 53 pp. 1039-1042.

Barua, D., Deka, A. and Dey S. K. 1983. Evaluating the influence of clonal variations, shade and nitrogenous fertiliser on nitrate reductase activity in tea. *Journal of Plantation Crops* (in press).

Ghosh, P., Phukan D.S., Saikia, B. P. and Dey, S. K. 1983. Results of water table survey for diagnosis of sub-soil drainage problem. *Agri. Engineering Today* (in press).

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 1. Tocklai Experimental Station (MID ASSAM)

Latitude : 26° 47' N Longitude : 94° 12' E Altitude : 96.5 meter a.m.s.l

Months	Temperature °C						Rainfall mm		Days with Rain 0.3mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0613 hrs (IST)			at 1313 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min	Total monthly	Normal		Mean daily	Normal	Mean daily (KM)	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	24.4	10.6	22.4	9.4	27.7	8.8	0.0	21.2	0	7.0	5.9	22.4	23.1	15.2	16.8	19.0	23.6	19.7	18.4
Feb.	22.1	12.0	24.0	12.0	27.8	8.4	39.1	31.8	8	5.7	6.3	36.0	36.4	15.7	17.3	19.3	23.6	20.2	19.3
Mar.	27.2	15.3	27.5	15.5	33.0	11.7	18.0	77.2	7	7.4	6.8	45.7	52.5	19.6	21.3	23.1	29.0	24.3	23.2
April	26.4	18.8	28.6	19.1	31.4	16.6	230.1	193.2	22	4.7	5.9	42.8	59.1	21.8	22.4	23.8	27.4	25.0	24.0
May	31.4	22.5	29.9	21.9	36.1	19.0	116.6	278.3	14	7.3	5.1	42.5	52.1	25.1	26.7	28.0	34.6	30.4	28.2
June	31.4	24.4	31.6	24.2	36.3	22.5	455.1	329.4	26	4.0	4.6	40.6	54.6	27.8	28.3	29.4	34.0	30.9	29.4
July	32.4	25.3	32.2	24.7	35.2	23.8	364.6	381.6	26	4.7	4.8	49.3	58.7	28.5	29.0	30.1	34.3	31.4	30.1
Aug.	32.6	25.1	32.1	24.6	35.2	23.2	371.4	343.6	25	6.1	5.1	34.6	49.4	28.8	29.5	30.6	35.3	32.0	30.7
Sep.	31.2	24.4	31.3	24.0	35.4	22.4	262.0	255.1	21	4.1	5.1	40.9	40.6	27.8	28.2	29.5	33.9	30.7	29.7
Oct	30.0	20.7	29.4	21.0	31.6	18.0	28.3	117.1	8	7.3	5.7	18.8	29.1	24.6	25.6	27.5	23.1	29.2	27.8
Nov.	26.4	15.6	26.4	15.3	29.5	10.0	28.1	27.7	6	6.6	6.1	18.4	20.3	19.9	21.3	23.6	27.6	24.4	23.7
Dec.	21.9	11.9	23.4	10.7	24.5	5.4	48.9	11.8	10	4.7	6.0	16.4	17.9	15.8	17.1	19.3	21.9	19.3	19.3

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 2. Margherita (UPPER ASSAM)

Latitude : 26.1 7'N Longitude : 95° 32' E Altitude : 183.0 meter a.m.s.l.

Months	Temperature °C						Rainfall mm		Days with Rain 0.3mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0608 hrs (IST)			at 1308 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	23.7	9.0	22.7	8.6	26.8	7.0	13.2	26.8	3	6.8	6.5	39.2	42.0	13.9	16.8	18.5	23.6	18.9	18.7
Feb.	22.6	10.8	23.3	11.0	26.8	6.6	70.3	56.7	15	5.6	6.3	56.3	52.1	14.7	17.2	18.6	22.2	19.0	18.7
March	26.7	14.0	26.2	14.3	31.8	9.9	91.4	156.4	12	6.8	6.4	58.7	55.4	18.4	20.5	21.6	27.7	22.7	21.9
April	28.9	17.8	28.6	18.0	30.7	15.0	356.8	269.3	25	3.9	5.3	61.5	63.3	21.3	22.4	23.3	27.8	24.2	23.4
May	31.2	20.6	30.6	20.9	35.8	17.4	259.8	236.8	16	7.1	5.8	54.1	51.1	25.9	26.8	27.4	34.3	29.3	27.6
June	31.3	23.5	32.2	23.7	36.9	22.7	387.0	419.8	24	2.9	4.9	49.2	48.4	27.4	28.3	29.0	33.8	30.2	29.1
July	31.4	24.2	31.3	24.3	34.8	23.0	646.5	602.0	27	3.2	3.4	52.2	48.9	28.8	29.5	30.2	34.6	31.7	30.2
Aug.	33.2	24.5	32.1	24.2	36.3	22.5	268.0	372.1	19	5.7	4.6	44.0	45.2	28.9	29.9	30.7	35.9	32.5	31.0
Sept.	31.0	23.6	31.0	23.2	35.6	22.0	219.6	352.8	15	3.6	4.6	39.5	38.8	27.5	28.5	29.5	33.8	30.8	29.6
Oct.	29.9	19.2	29.4	19.5	31.6	15.5	79.5	124.4	8	7.2	6.9	30.0	33.3	24 0	25.9	27.3	33.1	28.1	27.5
Nov.	26.2	14.0	26.9	14.4	29.5	8.4	43.6	25.8	4	7.2	7.4	32.3	32.6	18.6	21.9	23.4	27.6	23.7	23.5
Dec.	21.5	10.5	22.7	10.1	23.9	4.0	37.8	30.6	8	4.4	5.8	33.8	36.4	14.6	17.2	19.2	21.8	19.2	19.1

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 3. Thakurbari (NORTH BANK)

Latitude : 26° 49′N Longitude : 92° 43′ E Altitude : 92.4 meter a.m.s.l.

Months	Temperature °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0619 hrs (IST)			at 1319 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	25.6	10.1	24.0	8.7	28.9	8.0	0.0	18.2	0	7.8	7.6	21.3	34.8	15.0	17.1	19.0	24.5	20.3	19.1
Feb.	23.7	11.6	25.8	11.5	29.1	8.0	28.2	16.3	5	6.7	7.2	63.2	62.6	15.8	17.5	19.4	22.9	20.5	19.4
March	29.5	15.0	29.8	15.2	35.2	10.8	24.5	44.3	6	7.6	7.8	78.5	99.4	20.2	21.8	23.1	29.2	25.5	23.3
April	28.0	18.9	33.5	19.3	33.1	16.0	140.5	155.0	21	5.2	6.7	104.7	118.0	21.2	22.9	24.2	28.7	25.5	24.2
May	32.1	21.7	31.1	21.5	37.0	19.1	201.7	229.8	15	7.6	6.2	78.8	72.2	25.6	26.7	27.6	33.7	29.9	27.7
June	31.4	24.4	32.0	24.3	36.3	22.3	503.7	439.4	22	3.9	4.8	60.4	68.2	27.3	27.9	28.6	32.7	30.1	28.6
July	32.0	25.2	32.3	24.9	36.0	23.9	413.8	521.8	26	4.0	4.7	60.8	62.1	25.9	28.6	29.1	32.9	30.5	29.5
Aug.	32.7	25.4	32.7	25.0	36.5	24.0	223.2	270.5	15	6.7	5.5	37.2	57.1	28.7	29.8	30.6	35.9	32.7	30.9
Sept.	31.1	23.8	31.9	23.6	35.8	22.0	283.5	329.0	16	4.1	5.4	56.4	45.1	26.8	27.8	28.8	32.1	29.9	28.0
Oct.	31.1	19.5	30.4	20.2	31.0	9.2	35.0	120.5	3	8.3	7.3	28.5	32.7	23.7	25.6	27.2	33.8	29.7	27.6
Nov.	27.5	14.2	28.0	14.8	31.0	9.2	13.5	17.6	3	7.8	7.8	25.4	25.2	19.1	21.3	23.4	29.0	25.2	23.7
Dec.	23.7	11.4	24.9	9.9	26.1	4.5	2.2	20.0	3	6.0	7.9	29.0	25.5	16.4	17.7	19.3	24.0	21.3	20.0

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 4. Silcoorie (CACHAR)

Latitude : 24° 50′N Longitude : 92° 48′ E Altitude : 39.6 meter a.m.s.l.

Months	Temperature °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0619 hrs (IST)			at 1319 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	26.2	11.5	25.7	10.5	29.9	10.0	0.0	16.5	0	8.5	8.0	38.9	37.3	16.9	?	22.0	27.9	?	22.6
Feb.	26.4	13.9	27.4	12.9	29.1	9.5	83·8	50.1	5	7.7	8.2	61.8	59.8	17.9	?	22.8	28.5	?	23.1
March	30.1	16.3	30.5	16.6	33.9	11.6	89.0	112.4	6	8.4	8.1	81.2	79.0	20.4	?	25.2	33.0	?	26.0
April	28.6	20.5	31.4	20.5	32.7	18.0	793.5	305.1	29	6.8	7.6	98.8	88.7	23.0	?	26.1	31.0	?	26.8
May	32.4	23.3	31.6	22.7	36.9	19.5	376.5	408.8	13	8.5	6.9	78.7	78.4	27.2	?	?	36.3	?	?
June	31.8	24.7	31.5	24.4	36.4	22.4	539.6	585.8	25	4.7	4.6	68.2	66.6	22.3	?	?	34.7	?	?
July	31.1	24.6	31.9	24.9	34.7	22.2	483.6	513.3	29	4.0	4.5	68.4	67.6	28.3	?	?	34.4	?	?
Aug.	33.0	25.2	32.2	24.9	35.4	24.2	298.0	416.3	21	6.3	5.1	60.6	57.8	28.6	?	?	36.8	?	?
Sept.	31.5	24.6	32.1	24.4	36.4	22.2	244.1	334.1	19	4.5	5.7	41.9	53.6	27.4	?	?	34.3	?	?
Oct.	31.9	22.7	31.3	22.4	34.9	20.0	43.1	182.8	7	7.9	6.8	32.4	40.1	26.0	?	?	35.5	?	30.6
Nov.	28.8	17.3	29.3	17.6	33.6	11.6	29.8	33.8	4	7.8	7.8	31.4	34.8	21.2	?	?	31.2	?	?
Dec.	26.0	12.4	26.7	12.6	27.3	9.2	8.0	9.9	1	8.2	8.1	34.6	32.7	17.1	?	?	27.7	?	?

? indicates data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 5. Nagrakata (DOOARS)

Latitude : 26° 54' N Longitude : 88° 55' E Altitude : 228.6 meter a.m.s.l.

Months	Temperature °C					Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
													at 0634 hrs (IST)			at 1334 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	24.8	11.8	23.5	10.6	28.5	10.0	0.0	13.1	0	7.3	7.5	81.6	80.9	14.9	18.2	20.2	26.2	20.4	20.8
Feb.	24.4	12.0	25.2	12.8	28.3	8.6	16.7	24.4	3	6.3	7.3	80.9	91.9	15.6	18.7	20.9	26.8	21.1	21.1
March	28.3	15.1	29.2	16.2	33.9	10.0	62.9	44.4	6	6.3	7.5	106.2	111.2	18.9	22.3	24.0	31.6	25.0	24.4
April	28.9	19.5	30.8	20.0	34.4	15.5	161.8	144.7	18	6.5	7.0	111.8	120.2	21.5	23.8	25.5	32.3	26.7	25.7
May	31.9	21.1	30.6	21.7	35.5	18.1	301.3	358.5	17	8.4	6.6	105.6	107.3	25.2	26.7	28.6	34.3	29.7	28.4
June	30.5	23.3	30.5	23.7	32.9	21.3	798.9	850.7	24	3.8	4.1	79.3	85.9	27.1	28.0	29.1	32.4	29.8	29.2
July	30.2	23.5	30.3	23.9	33.9	21.7	1293.2	1025.6	28	3.6	3.4	71.0	80.6	26.2	28.0	28.0	30.6	29.2	?
Aug.	31.6	23.9	30.9	23.8	33.9	23.0	379.6	726.3	28	5.0	4.2	81.1	77.6	28.2	28.8	?	32.9	30.7	?
Sept.	29.5	22.8	30.6	22.8	35.0	21.3	319.7	561.0	18	4.5	5.1	61.3	69.0	27.3	29.5	?	31.9	29.6	?
Oct.	30.8	18.5	29.8	19.5	31.7	16.4	45.8	210.6	5	8.1	7.8	59.7	67.4	24.6	26.2	?	31.0	28.6	?
Nov.	26.5	15.0	27.4	15.0	30.0	10.2	36.6	23.9	8	7.0	8.4	98.8	73.1	20.7	22.1	?	24.8	27.9	?
Dec	23.6	11.4	24.7	11.6	25.6	6.6	31.0	7.0	4	6.4	8.2	39.4	72.4	16.3	18.0	?	22.6	19.8	?

? indicate data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 6. Chuapara (DOOARS)

Latitude : 26° 44' N Longitude : 89° 28' E Altitude : 190.8 meter a.m.s.l.

Months	Temperature °C						Rainfall mm		Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0632 hrs (IST)			at 1332 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	26.6	9.9	25.2	?	30.1	8.7	0.0	6.0	0	7.4	6.6	54.0	56.8	13.5	17.1	?	24.1	20.2	?
Feb.	26.7	10.4	26.2	?	29.8	6.6	6.2	5.1	3	6.8	6.8	75.5	76.9	14.7	18.4	?	25.8	21.8	?
March	29.2	13.9	29.3	?	34.3	8.5	113.8	96.7	6	6.7	6.8	80.4	82.9	18.2	21.0	?	29.4	24.9	?
April	30.3	18.1	30.8	?	34.1	15.1	245.6	160.4	15	7.0	7.0	68.3	70.2	21.9	23.9	?	31.7	27.8	?
May	32.5	?	31.7	?	33.9	?	328.4	278.2	16	8.8	7.7	62.5	60.5	24.7	27.9	?	34.8	29.2	?
June	31.0	?	31.9	?	33.8	?	690.0	765.2	20	1.6	4.5	51.5	52.0	26.5	27.9	?	32.6	30.1	?
July	31.0	?	31.9	?	35.3	?	1234.0	1025.3	27	2.5	3.6	46.7	47.2	26.1	27.6	?	31.8	29.7	?
Aug.	33.0	?	32.2	?	35.5	?	301.2	534.4	18	5.3	4.8	46.5	44.8	27.6	29.1	?	34.8	33.3	?
Sept.	32.1	?	32.1	?	37.0	?	279.4	494.4	16	4.3	5.0	33.6	37.0	26.6	28.1	?	34.0	31.0	?
Oct.	32.7	?	31.8	?	33.3	?	6.0	45.2	1	7.8	7.9	48.7	44.2	21.6	24.3	?	34.4	29.9	?
Nov.	28.0	?	29.7	?	33.3	?	3.4	1.1	2	6.7	7.9	44.1	46.8	18.1	21.1	?	28.5	25.4	?
Dec.	25.0	?	26.1	?	27.2	?	8.6	6.6	2	6.2	6.9	46.2	47.5	14.6	17.5	?	23.1	21.1	?

? indicate data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 7. Gungaram (TERAI)

Latitude : 26° 32'N Longitude : 48°42'E Altitude : 123.6 meter a.m.s.l

Months	Temperature °C					Rainfall mm			Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0631 hrs (IST)			at 1353 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	25.3	8.7	23.6	9.0	26.5	7.2	0.0	4.7	0	7.5	7.6	39.5	48.4	12.5	15.5	17.9	25.8	19.0	18.6
Feb.	25.1	11.2	25.6	11.1	28.0	8.0	0.0	6.8	0	7.6	8.0	68.5	66.8	14.7	17.8	18.7	26.4	19.6	19.2
March.	29.0	15.0	30.1	14.9	33.8	12.3	51.3	24.5	5	7.6	8.5	83.7	97.6	19.3	21.0	21.5	31.8	24.6	22.8
April	30.8	18.2	31.6	19.7	36.5	16.4	148.2	104.5	13	8.4	8.2	99.1	113.3	23.2	25.2	26.4	34.4	29.2	27.3
May	33.5	21.0	31.5	21.9	37.1	19.0	289.2	260.8	7	9.7	7.9	71.6	91.4	25.9	27.5	29.3	36.6	31.7	30.1
June	31.4	22.4	31.7	23.5	34.4	20.6	720.9	446.1	22	5.8	6.5	59.3	80.2	26.4	27.6	28.9	34.5	30.6	29.5
July.	30.0	19.2	30.6	23.8	33.4	20.9	1568.8	1025.2	28	4.5	4.5	46.6	70.2	25.7	26.6	27.2	31.6	29.6	27.7
Aug.	33.0	23.4	32.0	24.6	36.2	22.1	179.0	559.2	19	6.2	5.9	49.6	62.7	28.3	29.5	30.6	35.0	32.4	31.3
Sept	30.6	22.2	31.1	23.5	34.4	20.1	242.6	389.6	17	5.0	5.7	22.8	46.3	26.7	27.9	29.1	32.9	31.2	28.8
Oct.	31.1	20.7	30.5	20.1	33.0	18.3	68.7	97.0	2	8.4	8.2	20.7	36.6	24.9	26.2	27.2	33.8	31.1	27.9
Nov.	29.4	14.6	28.5	15.2	31.0	10.3	7.8	23.3	1	6.7	8.0	25.5	33.6	19.3	22.0	23.4	30.6	26.9	24.1
Dec	24.6	9.8	25.3	10.6	28.0	7.6	0.0	18.1	0	7.6	7.8	31.3	36.7	12.9	16.3	18.9	24.8	19.5	19.1

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1982

Table 8. Nagri-Farm (DARJEELING)

Latitude : 26° 55'N Longitude : 88° 12'E Altitude : 1,158.2 meter a.m.s.l.

Months	Temperature °C					Rainfall mm			Days with Rain 0.3 mm & above	Sunshine hours		Wind speed in KM		Soil Temperature Bare °C					
														at 0737 hrs (IST)			at 1437 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max	Normal Min.	Highest Max.	Lowest Min	Total monthly	Normal		Mean daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5cm	15 cm	30 cm
Jan.	17.0	9.2	15.1	7.8	20.5	7.2	0.0	16.9	0	6.4	6.0	94.7	92.9	9.3	12.1	?	20.4	16.0	?
Feb.	16.0	8 6	16.7	9.4	20.3	4.4	21.8	21.2	8	5.0	5.7	109.4	105.4	9.4	11.5	?	19.4	15.0	?
March	19.8	12.1	21.3	13.0	24.7	7.4	44.1	50.0	6	5.1	6.9	134.0	142.6	13.0	14.7	?	23.2	18.8	?
April	21.3	14.6	23.4	15.7	27.0	21.4	142.8	101.5	16	4.8	5.7	129.1	136.0	15.0	16.4	?	23.8	19.9	?
May	24.6	17.4	23.9	17.0	27.4	15 8	154.2	193.1	13	6.8	5.2	127.6	101.3	18.3	20.0	?	28.1	24.5	?
June	24.1	18.7	24.2	18.8	26.6	17.8	427.5	417.8	23	3.2	3.1	87.8	81.1	20.8	21.7	?	28.3	24.9	?
July	24.5	19.3	24.3	19.3	27.2	17.5	342.5	640.4	27	2.1	2.4	77.6	76.8	21.6	22.2	?	27.7	24.6	?
Aug.	25.4	19.6	24.8	19.2	28.2	18 0	218.9	449.6	19	4.5	3.4	85.9	72.3	21.9	23.2	?	29.5	25.7	?
Sept.	24·2	18.3	24.1	18.2	28.4	16.5	194 4	304.0	18	3.3	3.9	82.9	73.1	20.0	21.6	?	27.5	24.5	?
Oct.	22.9	15.3	22.8	15.7	25.7	13.0	84.6	130.7	5	7.4	6.6	78.0	77.8	16.4	19.4	?	28.8	24.0	?
Nov.	18.8	11.8	20.4	12.6	22.6	8.1	13.0	11.5	8	4.7	7.0	69.5	78.4	12.7	15.5	?	21.5	18.6	?
Dec.	16.3	8.6	17.4	9.6	19.3	5.2	0.0	8.5	0	5.3	6.7	78.4	81.4	8.8	11.8	?	19.5	15.2	?

? indicates data not available

Table 9. Total monthly Evaporation in mm (U.S. Pan) of North East India Tea Areas during 1982

Area	Stations	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Assam Valley South Bank	Margheritta	30.9	35.5	65.5	40.6	90.7	49.9	44.9	77.8	51.4	59.7	39.3	23.6
	Tocklai	34.6	47.6	90.1	63.4	104.6	82.3	94.8	85.9	68.2	63.9	44.4	27.2
	Difloo	54.0	58.2	110.2	98.1	125.3	114.7	123.7	84.4	67.7	65.7	54.1	36.4
	Kellyden	83.2	69.9	92.8	106.1	117.8	129.9	147.7	153.1	131.2	92.4	71.9	51.4
Assam Valley No th Bank	Monabari	73.6	75.9	97.4	104.1	130.2	121.1	116.9	113.4	86.1	92.6	96.0	81.9
	Thakurbari	43.2	61.1	110.5	93.2	114.7	94.0	88.2	110.0	70.1	79.2	53.8	39.8
	Julia	48.6	64.1	125.0	119.3	113.9	131.6	105.2	104.9	113.3	92.6	80.3	75.7
	Mornoi	40.4	65.0	108.5	115.2	133.9	99.9	144.2	131.8	107.2	89.6	59.3	44.0
Cachar	Koomber	63.0	67.4	101.6	83.7	113.5	159.5	132.4	103.4	107.0	97.9	85.3	81.6
	Silcoorie	62.9	71.1	108.7	75.6	129.2	100.1	91.0	120.5	76.7	88.5	61.8	50.6
	Hattiknira	58.0	73.5	104.3	124.0	139.3	108.1	99.5	127.7	102.3	84.2	61.9	46.9
North Bengal	Chuapara	51.4	66.9	101.5	111.4	119.2	90.8	76.9	88.9	100.6	104.3	77.0	73.2
	Nagrakata	59.9	84.5	144.0	127.7	129.2	103.6	100.8	121.2	90.1	108.6	66.0	50.3
	Gungaram	45.2	76.1	112.2	137.3	136.2	79.2	62.1	96.8	71.3	65.2	44.0	41.8
	Nagri-Farm	46.7	50.9	90.7	76.3	112.1	64.0	62.8	80.8	60.5	77.9	38.5	38.5